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Alberta Heavy Oil, Oil Sands and Enhanced Recovery

**Experimental Pilot Projects
February, 1990**

Alberta

OIL SANDS TECHNOLOGY
AND RESEARCH AUTHORITY



JAN 30 1991

Alberta Heavy Oil, Oil Sands and Enhanced Recovery

**Experimental Pilot Projects
February, 1990**

A Survey Compiled by:

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Technology Transfer and Commercialization

Acknowledgments

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Summary

The 1990 survey provides detailed coverage of all of Alberta's sixty-five active or recently suspended in situ heavy oil, oil sands and enhanced oil recovery pilot projects. Twelve of the sixty-five are recent or new experimental horizontal drilling projects. Each pilot project listed contains the following information:

- a detailed reservoir description
- a detailed field facilities description
- well pattern
- project-specific description of EOR process employed
- historical documentation of the engineering events associated with the project
- description of important adjustments made to improve the process performance.


AOSTRA participates in 19 of the projects and operates the Underground Test Facility.

Also enclosed is an AOSTRA Advanced Oil Recovery Technologies Wallchart.

Acknowledgements

AOSTRA gratefully acknowledges the cooperation of all the operators who provided the information contained in this survey. Once again, we have been able to secure 100% participation.

If you have any comments on how the survey can be improved, please contact AOSTRA/Calgary at (403) 297-3380.



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PILOT PROJECTS IN ALBERTA

February, 1990

Operator

Sector

Alberta Energy Company Ltd.

Ipiatik Lake Phase A
Ipiatik Lake Phase B (New)
Suffield I*
Suffield II*
Suffield Horizontal
Suffield Horizontal Well #2 (New)
Suffield Hot Water Flood*

Alberta Oil Sands Technology
and Research Authority

Athabasca*

Amoco Canada Petroleum
Company Ltd.

Atlee Buffalo
Brintnell
Cessford*
David
Drumheller Horizontal Well (New)
Gregoire Lake*
Morgan
Soars Lake (Beaverdam) New Project
Soars Lake (Beaverdam)

Bow Valley Industries Ltd.

Marie (Cold Lake)*

BP Canada Inc.

Chauvin South Sparky 'E'
Marguerite Lake*
Project Owl

(Petro-Canada 50%)

Bumper Development
Corporation Ltd.

Twining Rundle 'A' Pool*

Canadian Hunter Exploration
Ltd.

Swan Hills Beaverhill Lake*

Canada Northwest Energy Ltd.

Atlee Buffalo

Canadian Occidental Petroleum
Ltd.

Manatokan
Morgan

CS Resources Ltd.

Pelican (New)

Chevron Canada Resources Ltd.

Taber

Esso Resources Canada Ltd.

Fisher Creek
Leduc
Leming
May/Ethel

	Rainbow Redwater
Excel Energy Inc.	Ardmore
Gulf Canada Resources Ltd.	Fenn-Big Valley*
Home Oil Company Ltd.	Kitscoty
Husky Oil	Caribou Lake Project (New) Kearl Lake*
Koch Exploration Canada Ltd.	Fort Kent
Mazzei Oil & Gas Ltd.	Frog Lake (New)*
Mobil Oil Canada, Ltd.	Iron River Kitscoty Wolf Lake Wolf Lake Extension (New)
Murphy Oil Company Ltd.	Lindbergh Morgan
Norcen Energy Resources Ltd.	Lindbergh I Lindbergh II Lindbergh III Horizontal Well (New) Provost (Bodo)*
PanCanadian Petroleum Ltd.	Countess B* Lindbergh Lindbergh - Elk Point
Petro-Canada Resources	Hangingstone I Hangingstone II Hangingstone III PCEJ (New)* Viking-Kinsella B
Renaissance Energy Ltd.	Horizontal Well (New)
Signalta Resources Ltd.	Pembina-Lobstick
Vikor Resources Ltd.	Joffre I* Joffre II*
Ulster Petroleums Ltd.	Retlaw*

* AO STRA Participation

Alberta Energy Company

Ipiatik Lake Phase A

LOCATION

LSD ____ Section: 1 Township: 73 Range: 6 W4M

PARTNERS:

Alberta Energy Company Limited	60%
Amoco Canada Petroleum Company Ltd.	30%
Deminex (Canada) Limited	10%

PROCESS: Cyclic Steam Stimulation

COST: Capital - \$24,000,000 wells/facility/roads

START-UP: Spring 1984

TERMINATION: Terminated 87-12-3

DESCRIPTION

WELL PATTERN: Skewed 7-Spot

WELL SPACING: 1.46 ha/2.44 ha

NO. OF WELLS:

Injection/Production	11
----------------------	----

Observation	2
-------------	---

(monitoring temperature via thermocouples)

FACILITIES

STEAM GENERATOR(S): one - 53 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Standard Pump Jacks

TREATER TYPE: Conventional Electrostatic Treater

STORAGE FACILITIES: Field Tanks

TRANSPORT: Rail Transport

RESERVOIR

Geological Horizon:	Wabiskaw
---------------------	----------

Depth to Top of Formation:	450 m.KB
----------------------------	----------

Reservoir Thickness:	
net:	25 m
gross:	29 m

Original Temperature:	16°C
-----------------------	------

Original Pressure:	2200 kPa
--------------------	----------

Average Horizontal Permeability:	n/a md
----------------------------------	--------

Average Porosity:	27%
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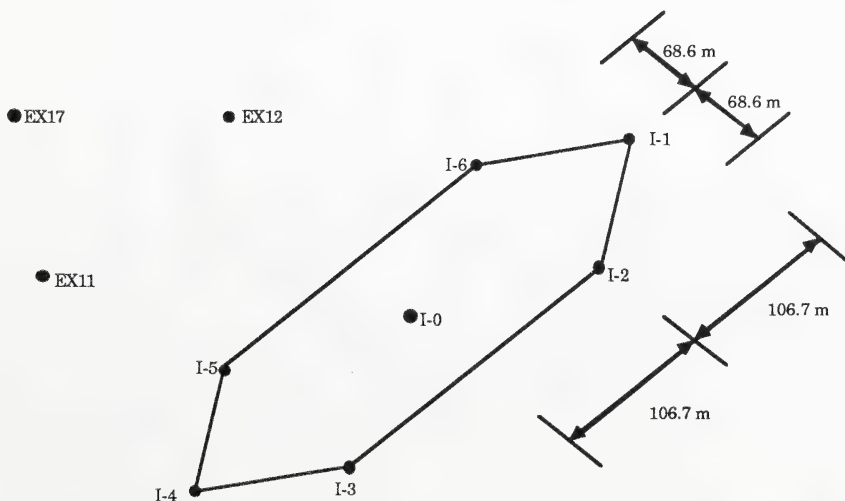
Average Water Saturation S_w	20%
--------------------------------	-----

Average Oil Saturation S_o	80% pore volume
------------------------------	-----------------

Oil Viscosity at Reservoir Temp.	n/a mPa.s
----------------------------------	-----------

Oil Gravity at Reservoir Temp.	993 Kg/m ³
--------------------------------	-----------------------

Primary Production Rates:	nil m ³ /well/day
Source:	Pilot Operator



Alberta Energy Company

Ipiatik Lake Phase B

LOCATION

LSD ____ Section: 2 Township: 73 Range: 6 W4M

PARTNERS:

Alberta Energy Company Limited
60%
Amoco Canada Petroleum Company Ltd.
30%
Deminex (Canada) Limited
10%

PROCESS: Cyclic Steam Stimulation

COST:

START-UP: January 1987

TERMINATION:

DESCRIPTION

PILOT AREA: 3.7 ha

WELL PATTERN: Regular 7-Spot

WELL SPACING: 2.43 ha

NO. OF WELLS: 7 Injection/Production

Note: Suspended 90-01-01

FACILITIES

STEAM GENERATOR(S): one - 53 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Standard Pump Jacks

TREATER TYPE: Conventional Electrostatic Treater

STORAGE FACILITIES: Field Tanks

TRANSPORT: Rail Transport

RESERVOIR

Geological Horizon: Wabiskaw

Depth to Top of Formation: 450 m.KB

Reservoir Thickness:

net: 25 m

gross: 29 m

Original Temperature: 16°C

Original Pressure: 2200 kPa

Average Horizontal Permeability: n/a md

Average Porosity: 27%

Average Water Saturation S_w : 20%

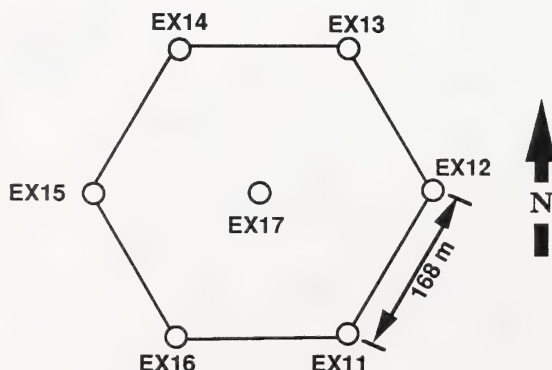
Average Oil Saturation S_o : 80% pore volume

Oil Viscosity at Reservoir Temp. n/a mPa.s

Oil Gravity at Reservoir Temp. 993 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator



Alberta Energy Company

Suffield I

LOCATION

LSD 4 Section: 10 Township: 20 Range: 8 W4M

PARTNERS:

AOSTRA	50%
Alberta Energy Company Ltd.	33.33%
Westcoast Petroleum Company Ltd.	16.66%

PROCESS: Wet Combustion

COST: Capital - \$8,989,000 (to Dec. 31/88)
Operating - \$7,481,000 (to Dec. 31/88)

START-UP: 1980

TERMINATION: February 1987, termination of wet combustion process. December 1988, termination of blowdown phase.

DESCRIPTION

PILOT AREA: 2 ha

WELL PATTERN: Inverted 5-Spot

WELL SPACING: 1 ha

NO. OF WELLS:

Injection	1 (1 - suspended)
Production	4 (2 - suspended)
Observation	3 (temperature monitoring only) (3 suspended)

FACILITIES

One air compressor - Capacity - 58,000 m³/d @ 15.9 MPa

ARTIFICIAL LIFT METHODS: Conventional Beam Pump

TREATER TYPE: Pressure Heater-Treater

STORAGE FACILITIES: Oil - 620 m³, Emulsion - 400 m³, Water - 620 m³

TRANSPORT: Truck

RESERVOIR

Geological Horizon: Glauconitic Sandstone

Depth to Top of Formation: 900 m.KB

Reservoir Thickness:
net: 20 m
gross: 60 m

Original Temperature: 32°C

Original Pressure: 10,275 kPa

Average Horizontal Permeability: 480 md

Average Porosity: 27%

Average Water Saturation S_w : 25%

Average Oil Saturation S_o : 75% pore volume

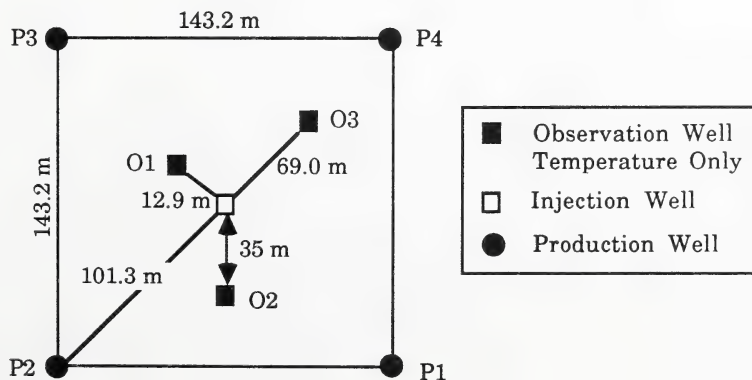
Oil Viscosity at Reservoir Temp. 850-5000 mPa.s

Oil Gravity at Reservoir Temp. 974-992 Kg/m³

Primary Production Rates: 1-10 m³/well/day

Source: Pilot Operator

COMMENTS: Phase A of Pilot Project completed December 31, 1986. Proceeding with Phase B of project which includes cyclic gas injection scheme, and blowdown of Phase A production wells which is reported separately.



Alberta Energy Company

Suffield II

LOCATION

LSD 11 Section: 34 Township: 19 Range: 8 W4M

PARTNERS:

Alberta Energy Company Limited
Westcoast Petroleum Ltd.
AOSTRA

PROCESS: Gas Injection Slug

START-UP: September 1987

TERMINATION: March 1988

DESCRIPTION

PILOT AREA: 2.86 ha

WELL PATTERN: Inverted 7-Spot

WELL SPACING: 0.9 ha/well

NO. OF WELLS:

Injection (Common Wellbore)

Production

1

6

FACILITIES

GAS COMPRESSOR(S): one; rental only, Capacity:
14,000 (m³/d @ 13.5 MPa)

ARTIFICIAL LIFT METHODS: Conventional Beam
Pumpjack

TREATER TYPE: Pressure Heater Treater with Colt
Evaporator Polisher

TRANSPORT: Pipeline

RESERVOIR

Location: 10-20-8W4

Geological Horizon: Glauconite Sandstone

Depth to Top of Formation: 899.5 m.KB

Reservoir Thickness:

net: 32 m

gross: 51 m

Original Temperature: 33°C

Original Pressure: 10515 kPa

Avg. Horizontal Perm.: 500-1000 md

Avg. Porosity: 27%

Avg. Water Saturation - S_w : 25%

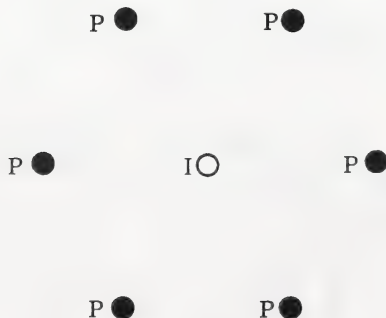
Avg. Oil Saturation S_o : 75 pore vol.

Oil Viscosity at Res. Temp. 395 mPa.s

Oil Gravity at Res. Temp. 970-975Kg/m³

Primary Production Rates: 1-15 m³/well/day

Source: Pilot Operator



Alberta Energy Company

Suffield Horizontal Well

LOCATION

LSD 6 Section: 34 Township: 19 Range: 8 W4M

PARTNERS:

Alberta Energy Company Limited	70%
Westcoast Petroleum Ltd.	30%

PROCESS: Horizontal Well

COST:

START-UP: October 1987

TERMINATION: In Progress

DESCRIPTION

PILOT AREA: Single well test (6-34-19-8 W4M) in Glauconite Sandstone

WELL PATTERN: Horizontal section extends 251 metres in oil pay.

WELL SPACING:

NO. OF WELLS: one

FACILITIES

ARTIFICIAL LIFT METHODS: Conventional Beam Pumpjack

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon:	Glauconite Sandstone
---------------------	----------------------

Depth to Top of Formation:	938 m.KB
----------------------------	----------

Reservoir Thickness:	
net:	15 m
gross:	18 m

Original Temperature:	30°C
Original Pressure:	10000 kPa

Average Horizontal Permeability:	1000 md
Average Porosity:	25%

Average Water Saturation S_w	25% pore vol.
Average Oil Saturation S_o	75% pore vol.

Oil Viscosity at Reservoir Temp.	395 mPa.s
Oil Gravity at Reservoir Temp.	9 7 0 - 9 7 5

Kg/m³

Primary Production Rates:	m ³ /well/day
Source:	Pilot Operator

Alberta Energy Company

Suffield Horizontal Well #2

LOCATION

LSD 6 Section: 3 Township: 20 Range: 8 W4M

PARTNERS:

Alberta Energy Company Limited	70%
Westcoast Petroleum Ltd.	30%

PROCESS: Horizontal Well

COST:

START-UP: February 1988

TERMINATION: In Progress

DESCRIPTION

PILOT AREA: Single well test (6-3-20-8 W4M) in Glauconite Sandstone

WELL PATTERN: Horizontal section extends 655 metres in oil pay.

WELL SPACING:

NO. OF WELLS: one

FACILITIES

ARTIFICIAL LIFT METHODS: Conventional Beam Pumpjack

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon: Glauconite Sandstone

Depth to Top of Formation: 938 m.KB

Reservoir Thickness:

net: 8 m

gross: m

Original Temperature: 30°C

Original Pressure: 10000 kPa

Average Horizontal Permeability: 1000 md

Average Porosity: 25%

Average Water Saturation S_w 25% pore vol.

Average Oil Saturation S_o 75% pore vol.

Oil Viscosity at Reservoir Temp. 395 mPa.s

Oil Gravity at Reservoir Temp. 9 7 0 - 9 7 5

Kg/m³

Primary Production Rates: m³/well/day

Source: Pilot Operator

Alberta Energy Company

Suffield Hot Water Flood

LOCATION

NW/4 Section: 3 Township: 20 Range: 8 W4M

PARTNERS:

Alberta Energy Company Limited
Westcoast Petroleum Ltd.
AOSTRA

PROCESS: Hot Water Flood

COST: Capital - \$620,000
Operating - \$900,000

START-UP: 1988

TERMINATION: 1990

DESCRIPTION

PILOT AREA: 0.5 ha

WELL PATTERN: Inverted 4-Spot

WELL SPACING: S/B 0.33 ha/well

NO. OF WELLS:

Injection

1

Production

3

FACILITIES

WATER HEATER: Indirect fired line heater (salt bath)

ARTIFICIAL LIFT METHODS: Beam Pump

TREATER TYPE: 4' x 24' 3 Phase Vertical

STORAGE FACILITIES: Central Battery

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon: Glauconite Sandstone

Depth to Top of Formation: 900 m.KB

Reservoir Thickness:

net: 33 m

gross: 60 m

Original Temperature: 32°C

Original Pressure: 10275 kPa

Average Horizontal Permeability: 500-1000 md

Average Porosity: 27%

Average Water Saturation S_w : 25%

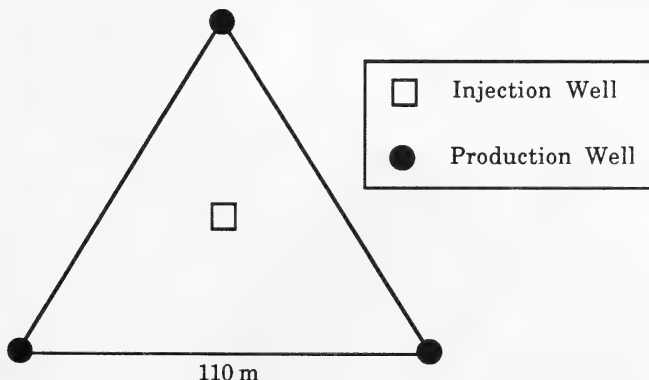
Average Oil Saturation S_o : 75% pore vol.

Oil Viscosity at Reservoir Temp. 400 mPa.s

Oil Gravity at Reservoir Temp. 970-975 Kg/m³

Primary Production Rates: 1-15 m³/well/day

Source: AOSTRA



AOSTRA

Underground Test Facility

LOCATION

LSD 2,3,14 & 15 Section: 7,18 Township: 93
Range: 12 W4M

PARTNERS:

Access Stage - 100% AOSTRA

Phase A Process Tests

- AOSTRA
- Amoco Canada Petroleum Company Ltd.
- Canadian Centre for Mineral & Energy Technology
- Chevron Canada Resources Limited
- Mobil Oil Canada
- Petro-Canada Inc.
- Shell Canada Limited
- Texaco Canada Resources Ltd.

HASDrive Process

- AOSTRA
- Chevron Canada Resources Limited

PROCESS: Shaft & Tunnel Access to Horizontal Well Drilling.

Horizontal Well Processes:

- (i) Steam-Assisted Gravity Drainage (SAGD)
- (ii) Heated Annulus Steam Drive (HASDrive)

COST: Capital: \$56,000,000 mine/wells/facilities/roads

START-UP:

Mine Access: September 1986

Phase A Processes: November 1987

TERMINATION:

Phase A estimated 1990

DESCRIPTION

- Phase A: 1.0 ha
- HASDrive: 0.3 ha

WELL PATTERN:

Phase A: - 3 pairs of horizontal wells; 160 m length; end 60 m completed
- 26 m between wellpairs

HASDrive: 160 m horizontal heating well; vertical injector at far end; horizontal producer 60 m back on heating well

OBSERVATION WELLS:

Phase A: 29 wells containing a mix of temperature and geotechnical instrumentation

HASDrive: 7 temperature observation wells

FACILITIES

MINE ACCESS:

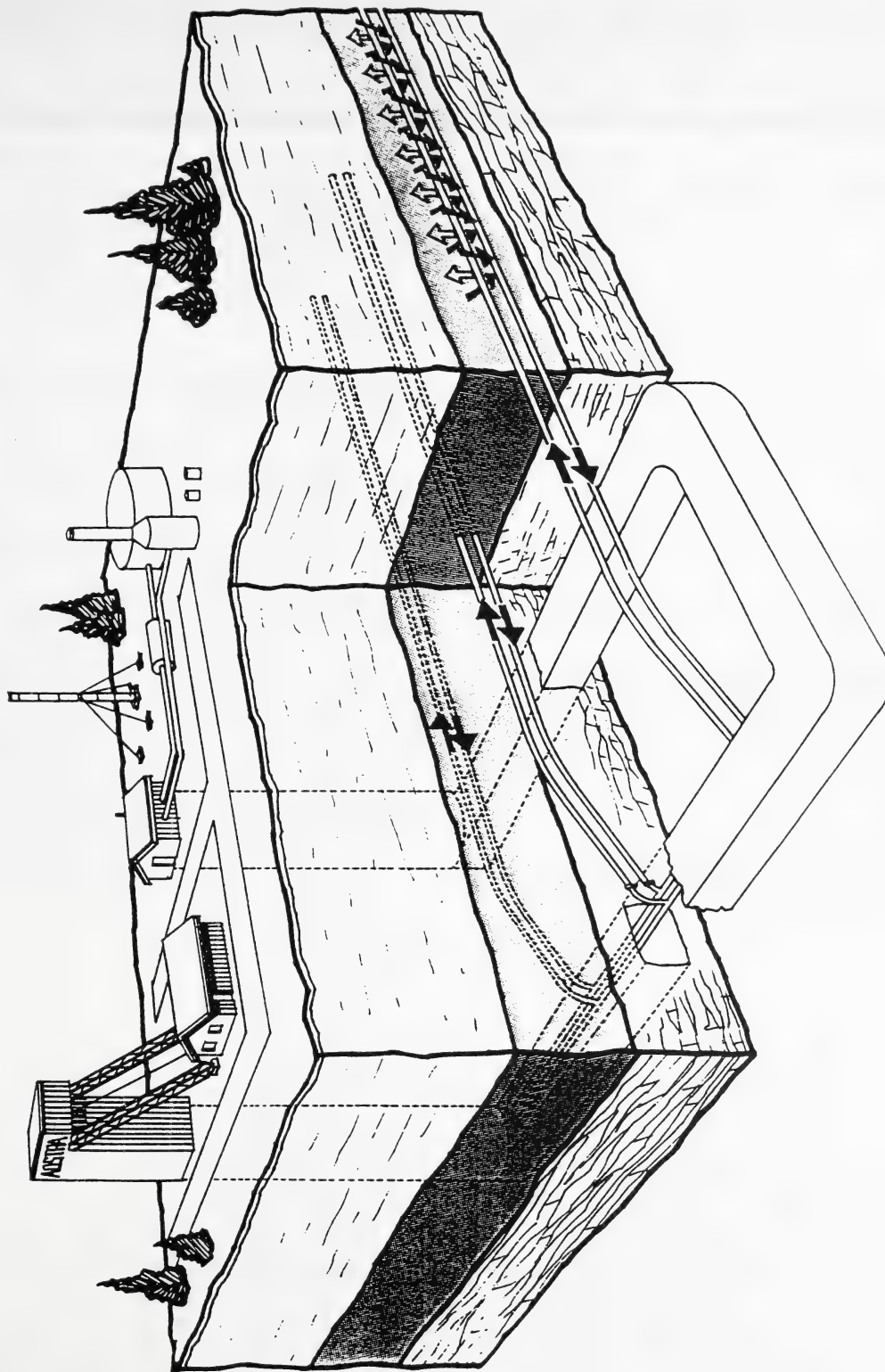
Two 3-4 m I.D. access shafts 213 m deep; 930 m of tunnel, 5 m wide x 4 m high cross-section; high speed hoist in #1 shaft

PROCESS:

One 7,000,000 BTU/hr and one 25,000,000 BTU/hr. steam generator; pumping or steam lift if required; simple gas separation & shipment of produced fluids.

RESERVOIR

Geological Horizon:	McMurray
Depth to Top of Formation:	135 m.KB
Reservoir Thickness:	
net:	22 m
gross:	m
Original Temperature:	11°C
Original Pressure:	450 kPa
Average Horizontal Permeability:	4000 md
Average Porosity:	35%
Average Water Saturation - S_w	19%
Average Oil Saturation S_o	81% pore vol.
Oil Viscosity at Reservoir Temp.	1,000,000 mPa.s
Oil Gravity at Reservoir Temp.	1014 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	AOSTRA



UNDERGROUND TEST FACILITY

Amoco Canada Petroleum Company Ltd.

Atlee Buffalo

LOCATION

LSD ___ Section: ___ Township: ___ Range: 5&6
W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd. 100%

PROCESS: Combination Thermal Drive

COST:

Capital - \$2.8 Million

Operating - \$1.5 Million for 1985

START-UP: July 1983

TERMINATION: November 1987 Project shutin due to low oil prices.

DESCRIPTION

PILOT AREA: 240 ha

WELL PATTERN: Two irregular inverted 9-Spot patterns

WELL SPACING: 15 ha/well

NO. OF WELLS:

Injection	2
Production	14
Observation	0

FACILITIES

One - 98,600 m³/d @ 12.4 MPa air compressor

ARTIFICIAL LIFT METHODS: Beam Pumps and Progressive Cavity Pumps

TREATER TYPE: Pressure treater

STORAGE FACILITIES: 1000 m³ oil, 160 m³ water, 160 m³ emulsion

TRANSPORT: Truck

RESERVOIR

Geological Horizon: Glauconite

Depth to Top of Formation: 915 m.KB

Reservoir Thickness:

net: 3.7 m

gross: m

Original Temperature: 30.6°C

Original Pressure: 10300 kPa

Average Horizontal Permeability: 1800 md

Average Porosity: 24%

Average Water Saturation - S_w: 34%

Average Oil Saturation S_o: 66% pore vol.

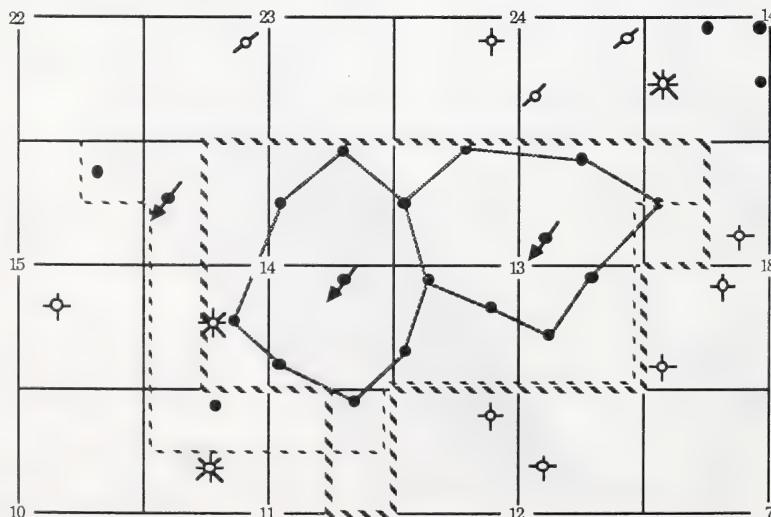
Oil Viscosity at Reservoir Temp.: 310 mPa.s

Oil Gravity at Reservoir Temp.: 965 Kg/m³

Primary Production Rates: 3.2 m³/well/day

Source: Pilot Operator

COMMENTS: Air is still being injected into the two patterns at rates of 100 MSCF/day/well.



Amoco Canada Petroleum Company Ltd.

Brintnell

LOCATION

LSD 6 Section: 24 Township: 81 Range: 23 W4M
LSD 10 Section: 15 Township: 81 Range 23 W4M
LSD: 5 Section: 1 Township: 81 Range 23 W4M
LSD: 7 Section: 23 Township: 80 Range 23 W4M
LSD: 5 Section: 24 Township: 80 Range 23 W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd. 100%

PROCESS: Steam Stimulation

COST: N/A

START-UP: November 1985

TERMINATION: March 1986 (reactivated in 1988)

DESCRIPTION

Single Well Cyclic Steam Stimulation Program

WELL SPACING: 64.75 ha

NO. OF WELLS:

Injection/Production 25

FACILITIES

STEAM GENERATOR(S): one - 22 GJ/hr steam generator - portable

ARTIFICIAL LIFT METHODS: Beam Pump and Progressive Cavity Pumps

STORAGE FACILITIES: 120 m³ Tanks

RESERVOIR

Geological Horizon:	Wabiskaw
Depth to Top of Formation:	425 m.KB
Reservoir Thickness:	
net:	7 m
gross:	15 m
Original Temperature:	28°C
Original Pressure:	2700 kPa
Average Horizontal Permeability:	n/a md
Average Porosity:	28%
Average Water Saturation S_w	35%
Average Oil Saturation S_o	65% pore vol.
Oil Viscosity at Reservoir Temp.	360 mPa.s
Oil Gravity at Reservoir Temp.	940 Kg/m ³
Primary Production Rates:	3 m ³ /well/day
Source:	Pilot Operator

COMMENTS

This project was suspended in March, 1986 due to low heavy oil prices and reactivated in 1988. Two horizontal wells were drilled in 1988.

Amoco Canada Petroleum Company Ltd.

Cessford

LOCATION

LSD __ Section: 34,27,23,11,10,3 Township: 25
Range: 12 W4M

PARTNERS:

Initial Phase:
Amoco Canada Petroleum Company Ltd. 54.1%
Esso 49.9%

Incremental Phase:
AOSTRA 50.0%
Amoco Canada Petroleum Company Ltd. 27.05%
Sulpetro 22.95%

PROCESS: Caustic Polymer Flood

COST:

Capital - 2,500,000

Operating - \$1,700,000/year

START-UP: Waterflooding in 1981, caustic flooding in July 1984, polymer flooding in January 1985.

TERMINATION: November 1992

DESCRIPTION

PILOT AREA: 260 ha

WELL PATTERN: Five 5-Spots and two line drive

WELL SPACING: 32 ha

NO. OF WELLS:

Injection	7
Production	19
Observation	0

FACILITIES

Water ion - exchange softeners with individual pumping units.

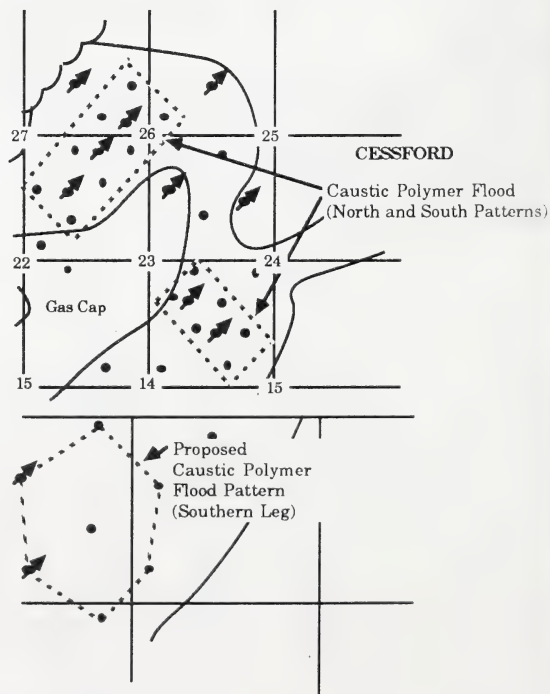
ARTIFICIAL LIFT METHODS: Conventional Beam Pumps

STORAGE FACILITIES: Tanks

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon:	Basal Colorado
	A Sandstone
Depth to Top of Formation:	884-905 m.KB
Reservoir Thickness:	
net:	4 m
gross:	4 m
Original Temperature:	30°C
Original Pressure:	8720 kPa
Average Horizontal Permeability:	200-400 md
Average Porosity:	24%
Average Water Saturation S_w	30%
Average Oil Saturation S_o	70% pore vol.
Oil Viscosity at Reservoir Temp.	24 mPa.s
Oil Gravity at Reservoir Temp.	912 Kg/m ³
Primary Production Rates:	n/a m ³ /well/day
Source:	Pilot Operator



Amoco Canada Petroleum Company Ltd.

David

LOCATION

LSD — Section: 2&11 Township: 41 Range: 3
W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd.	49%
Encor	24.75%
Others	

PROCESS: Alkaline Polymer Injection

COST: n/a

START-UP: 1986

TERMINATION: 1990

DESCRIPTION

PILOT AREA: 99 ha

WELL PATTERN: Irregular

WELL SPACING: 8 & 4 ha

NO. OF WELLS:

Injection	7
Production	21
Observation	0

FACILITIES

ARTIFICIAL LIFT METHODS: Pumps

TREATER TYPE: Pressure Treaters

STORAGE FACILITIES: Tanks

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon: Lloydminster

Depth to Top of Formation: 760 m.KB

Reservoir Thickness:
net: 3.2 m

gross: m

Original Temperature: 30.6°C

Original Pressure: 5580 kPa

Average Horizontal Permeability: 1480 md

Average Porosity: 29%

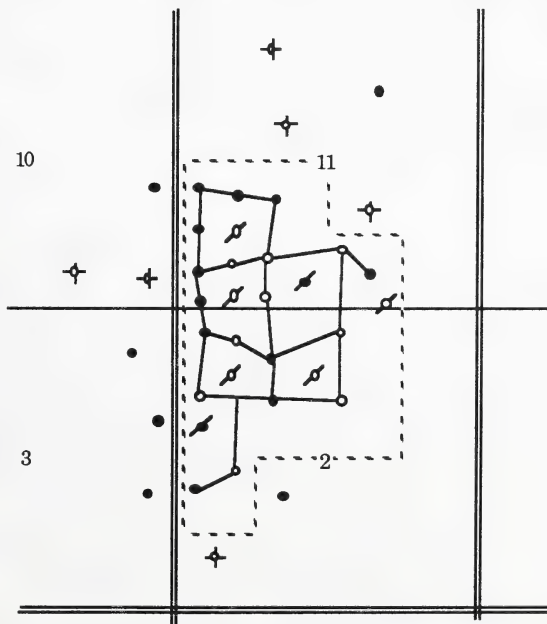
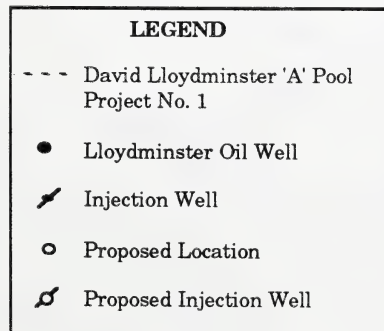
Average Water Saturation - S_w 27%

Average Oil Saturation S_o 73% pore vol.

Oil Viscosity at Reservoir Temp. 34.2 mPa.s

Oil Gravity at Reservoir Temp. 918 Kg/m³

Primary Production Rates: 12 m³/well/day
Source: Pilot Operator



Amoco Canada Petroleum Company Ltd.

Drumheller Horizontal Well

LOCATION

LSD 14 Section: 13 Township: 29 Range: 20 W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd.
Norcen Energy Resources Ltd.
Okanagan Petroleums Ltd.
Twin Richfield Ltd.
Voyager Energy Co.
N.L. Easley
S. Whipple

PROCESS: Short Radius Horizontal Well

COST: \$936,000

START-UP: January 15, 1988

TERMINATION: Rig Release February 18, 1988; On
Stream March 10, 1988

DESCRIPTION

PILOT AREA:

WELL PATTERN:

WELL SPACING: 80 acre in Sec. 13

NO. OF WELLS:

1 horizontal well drilled

FACILITIES

ARTIFICIAL LIFT METHODS: Reda Submersible
Pump

TREATER TYPE:

STORAGE FACILITIES:

TRANSPORT:

RESERVOIR

Geological Horizon:	Nisku/Dolomite
Depth to Top of Form.:	Porosity top~ 830 ASL
Reservoir Thickness:	
net:	5 m
gross:	30 m
Original Temperature:	56°C
Original Pressure:	13,338 kPa
Average Horizontal Permeability:	40 md
Average Porosity:	7.5%
Average Water Saturation S_w	20%
Average Oil Saturation S_o	80% pore vol.
Oil Viscosity at Reservoir Temp.	1.3 mPa.s
Oil Gravity at Reservoir Temp.	850 Kg/m ³
Primary Prod. Rates:	Confidential m ³ /well/day
Source:	

Amoco Canada Petroleum Company Ltd.

Gregoire Lake

LOCATION

LSD 5 Section: 2 Township: 86 Range: 7 W4M

PARTNERS:

AOSTRA	75%
Amoco Canada Petroleum Company Ltd.	12.5%
Petro-Canada Resources	12.5%

PROCESS: Steamflood with additives (CO₂ and/or Naphtha)

COST:

Initial Construction - \$7,460,000
Operating - \$14,500,000 (to Nov. 30/89)

START-UP: May 1985

TERMINATION: December 1989

DESCRIPTION

PILOT AREA: 0.28 ha

WELL PATTERN: Inverted 4-Spot

WELL SPACING: S/B 0.19 ha/well

NO. OF WELLS:

Injection	1
Production	3
Observation	3

FACILITIES

STEAM GENERATOR(S): one - 26.4 GJ/hr

ARTIFICIAL LIFT METHODS: Conventional Beam Pump

TREATER TYPE: Atmospheric tankage plus diluent

STORAGE FACILITIES: 400 m³ Bitumen/Diluent -
400 m³ Emulsion - 400 m³ Water

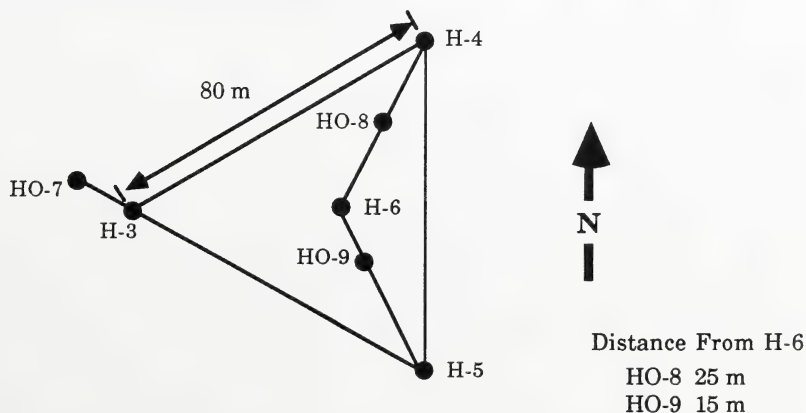
TRANSPORT: Truck

RESERVOIR

Geological Horizon:	McMurray
Depth to Top of Formation:	187 m.KB
Reservoir Thickness:	
net:	41 m
gross:	47 m
Original Temperature:	10°C
Original Pressure:	531 kPa
Average Horizontal Permeability:	n/a md
Average Porosity:	36.4%
Average Water Saturation - S _w	25%
Average Oil Saturation S _o	75% pore vol.
Oil Viscosity at Res. Temp.	850,000 (est) mPa.s
Oil Gravity at Reservoir Temp.	1018 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	Pilot Operator

COMMENTS:

Steaming operations initiated on October 27, 1986 to heat the production wellbores. A production cycle was started on January 16, 1987.



Amoco Canada Petroleum Company Ltd.

Morgan

LOCATION

LSD ____ Section: 35 Township: 51 Range: 4 W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd. 100%

PROCESS: Cyclic Steam/Combination Thermal Drive

COST:

Capital -\$22.3 Million

Operating - \$3.9 Million for 1987

START-UP: June 1981

TERMINATION: 1995

DESCRIPTION

PILOT AREA: 260 ha

WELL PATTERN: Inverted 7-Spot

WELL SPACING: 4 ha/well

NO. OF WELLS:

Injection	7
Production	39
Observation	0

FACILITIES

STEAM GENERATOR(S): two - 26 GJ/hr

AIR COMPRESSORS: one - 90,600 m³/d @ 6.9 MPa

ARTIFICIAL LIFT METHODS: HEP Units and liner pumps

TREATER TYPE: Pressure and Flash treaters

STORAGE FACILITIES: 1500 m³ oil; 800 m³ water

TRANSPORT: Husky Pipeline

RESERVOIR

Geological Horizon:	Lloydminster A
Depth to Top of Formation:	580 m.KB
Reservoir Thickness:	
net:	10 m
gross:	10 m
Original Temperature:	24°C
Original Pressure:	3230 kPa
Average Horizontal Permeability:	2000 md
Average Porosity:	30%
Average Water Saturation - S _w	25%
Average Oil Saturation S _o	75% pore vol.
Oil Viscosity at Reservoir Temp.	5688 mPa.s
Oil Gravity at Reservoir Temp.	973 Kg/m ³
Primary Production Rates:	2.2 m ³ /well/day
Source:	Pilot Operator

COMMENTS: Air injection is marginally profitable at low oil prices. An air pressure up blow down strategy is being used successfully. Conversion of a pattern to combination thermal drive to be done in 1990.

Amoco Canada Petroleum Company Ltd.

Soars Lake (Beaverdam) (New Project)

LOCATION

LSD 14 Section: 19 Township: 59 Range: 1 W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd. 100%

PROCESS: Steam Stimulation

COST: N/A

START-UP: June, 1988

TERMINATION:

DESCRIPTION

Single Well Cyclic Steam Stimulation Program

WELL SPACING: 4.047 ha

NO. OF WELLS:

Injection/Production	16
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Observation	1
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FACILITIES

STEAM GENERATOR(S): two 7.3 MW steam generators

ARTIFICIAL LIFT METHODS: HEP

STORAGE FACILITIES: Pressurized Treater, Treated Oil Trucked to Sales

RESERVOIR

Geological Horizon:	Sparky
Depth to Top of Formation:	450 m.KB
Reservoir Thickness:	
net:	10 m
gross:	20 m
Original Temperature:	22°C
Original Pressure:	2800 kPa
Average Horizontal Permeability:	1200 md
Average Porosity:	30%
Average Water Saturation - S_w	30%
Average Oil Saturation S_o	70% pore vol.
Oil Viscosity at Reservoir Temp.	20,000 mPa.s
Oil Gravity at Reservoir Temp.	985 Kg/m ³
Primary Production Rates:	2.0 m ³ /well/day
Source:	Pilot Operator

COMMENTS

Steaming above fracture pressure began in June, 1988. Well-to-well interference and sand production problems were initially severe. Steaming strategy and completions were revised in 1989 to reduce these problems.

Amoco Canada Petroleum Company Ltd.

Soars Lake (Beaverdam) Old Project

LOCATION

LSD ____ Section: 13,14,23,24,25,26,35,36

Township: 59 Range: 2 W4M

LSD ____ Section: 19 Township: 59 Range: 1 W4M

PARTNERS:

Amoco Canada Petroleum Company Ltd. 100%

PROCESS: Steam Stimulation

COST: N/A

START-UP: June 1, 1985

TERMINATION: June 1, 1987 (reactivated in 1988).

DESCRIPTION

Single Well Cyclic Steam Stimulation Program

WELL SPACING: 64.75 ha

NO. OF WELLS:

Injection/Production 18

FACILITIES

STEAM GENERATOR(S): one 7.3 MW portable steam generator

ARTIFICIAL LIFT METHODS: Beam Pump and Progressive Cavity Pump

STORAGE FACILITIES: 120 m³ Tanks

RESERVOIR

Geological Horizon: Sparky

Depth to Top of Formation: 450 m.KB

Reservoir Thickness:

net: 10 m

gross: 20 m

Original Temperature: 22°C

Original Pressure: 2800 kPa

Average Horizontal Permeability: 1200 md

Average Porosity: 30%

Average Water Saturation - S_w 30%

Average Oil Saturation S_o 70% pore vol.

Oil Viscosity at Reservoir Temp. 20,000 mPa.s

Oil Gravity at Reservoir Temp. 985 Kg/m³

Primary Production Rates: 2.0 m³/well/day

Source: Pilot Operator

COMMENTS

This project was suspended in March, 1986 due to low heavy oil prices and reactivated in 1988.

Currently attempting to create voidage before considering additional steaming.

Bow Valley Industries Ltd.

Marie (Cold Lake)

LOCATION

LSD 7 Section: 14 Township: 65 Range: 2 W4M

PARTNERS:

AOSTRA 50%
Bow Valley Industries Ltd. 50%
These are current participating interests.
Agreements between the parties provide for changes in interests as the project progresses through different phases.

PROCESS: Cyclic, frac assisted matrix injection scheme initially utilizing superheated steam, CO₂ and other chemical additives.

COST:

Capital: \$10,205,000

Operating: \$17,500,000

START-UP: January 15, 1985 (commencement of cyclic steam) Phase A, January 1987 for Phase AX

TERMINATION: December 31, 1990

DESCRIPTION

PILOT AREA: 8.8 ha for 2 patterns

WELL PATTERN: Skewed 7-Spot

WELL SPACING:

Initial Pilot: 0.9 ha spacing

Second Phase: 1.8 ha spacing

NO. OF WELLS:

Injection/Production 16

Observation 3

FACILITIES

STEAM GENERATOR(S): two - 94.78 GJ/hr

ARTIFICIAL LIFT METHODS: Rod actuated bottomhole pumps, tubing and conventional pumpjacks

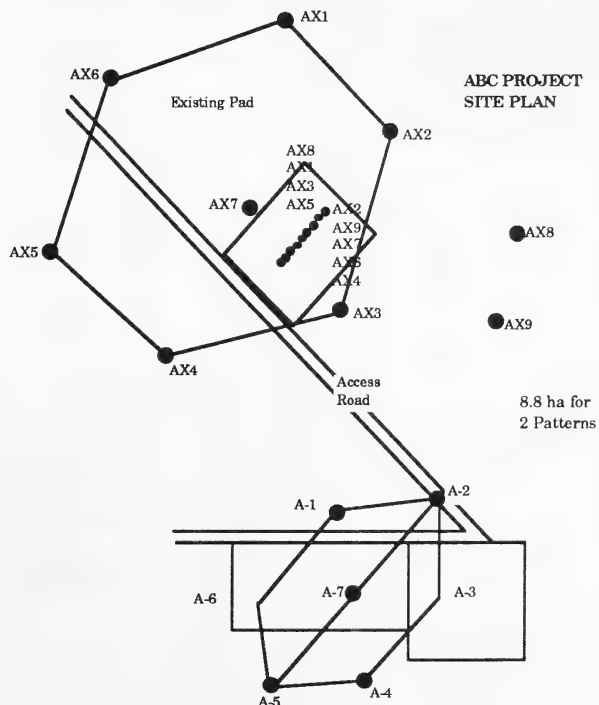
TREATER TYPE: Colt dehydrator

STORAGE FACILITIES:

FWKO = 318 m³, coalescing tank - 636 m³, settling tank = 119 m³, Sales Oil Tank - 795 m³, waste water skimmer tank - 318 m³, waste water storage tanks 476 m³

RESERVOIR

Geological Horizon:	Clearwater
Depth to Top of Formation:	420 m.KB
Reservoir Thickness:	
net:	(C-2 only) 8.5 m (C-3 only) 4.0 m
gross:	(C-2 only) 10.0 m (C-3 only) 4.0 m
Original Temperature:	11.5°C
Original Pressure:	3450 kPa
Average Horizontal Permeability:	2000 md
Average Porosity:	35%
Average Water Saturation - S _w	40%
Average Oil Saturation S _o	60% pore vol.
Oil Viscosity at Reservoir Temp.	500,000 mPa.s
Oil Gravity at Reservoir Temp.	1000 Kg/m ³
Primary Production Rates:	1 m ³ /well/day
Source:	AOSTRA



BP Canada

Chauvin South Sparky 'E'

LOCATION

LSD NW/4 Section: 24 Township: 42 Range: 3 W4M
 LSD SW/4 Section: 25 Township: 42 Range: 3 W4M
 LSD NE/4 Section: 26 Township: 42 Range: 3 W4M

PARTNERS:

BP Canada 100%

PROCESS: Mobility control polymer flood (using Xanthan - biopolymer)

COST:

Capital - \$370,000
 Operating - \$1,000,000 (chemical cost for 3 yrs. inj.)
 - \$120,000/yr (general)

START-UP: February 1988

TERMINATION: February 1992

DESCRIPTION

PILOT AREA: 794.25 ha

WELL PATTERN: 2 inverted 5-Spots; 1 partial peripheral injection pattern.

WELL SPACING: 16 ha

NO. OF WELLS:

Production	11
Injection (polymer)	3

FACILITIES

One polymer blending unit

ARTIFICIAL LIFT METHODS: Standard Pump Jack and Bottomhole Rotary Pumps

TREATER TYPE: Standard Heater/Treater

STORAGE FACILITIES:

1 - 210 bbl Formaldehyde tank

1 - 750 bbl polymer tank

TRANSPORT: All wells flowlined.

RESERVOIR

Geological Horizon: Third Sparky Sand of the Mannville Group

Depth to Top of Formation: 650 m.KB

Reservoir Thickness:

net: 3.0 m

gross: 3.2 m

Original Temperature: 29°C

Original Pressure: 4785 kPa

Average Horizontal Permeability: 1200 md

Average Porosity: 30%

Average Water Saturation - S_w 19%

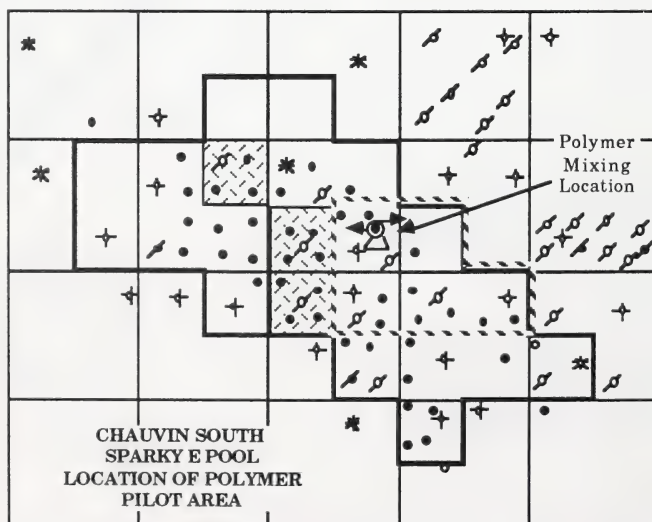
Average Oil Saturation S_o 81% pore vol.

Oil Viscosity at Reservoir Temp. 81 mPa.s

Oil Gravity at Reservoir Temp. 920 Kg/m³

Primary Production Rates: 8 m³/well/day

Source: BP



BP Canada

Marguerite Lake Phase A

LOCATION

LSD 8, 9, 16, 5, 12, 13 Section: 7,9 Township: 66
Range: 5 W4M

PARTNERS:

AOSTRA	50%
BP Canada (Operator)	50%

PROCESS: Wet Combustion with O₂

COST:

Capital - \$20,000,000
Operating - \$30,000,000

START-UP: June 1978

TERMINATION: April 1987

DESCRIPTION

PILOT AREA: 20 ha over 4 patterns

WELL PATTERN: Four 5-Spot patterns with subsequent in-fill drilling

WELL SPACING: Initial 2 ha spacing

NO. OF WELLS:

Test area: 3 combustion test wells (1 injector; 2 producers) Main pattern 5 injectors, 16 producers.

1 non-operational well; 12 observation wells: 12 (12 for temperature only; 2 for temperature and pressure)

FACILITIES

STEAM GENERATOR(S): two - 53 GJ/hr

ARTIFICIAL LIFT METHODS: Standard Pump Jack

TREATER TYPE: 8' x 30' Cenatco

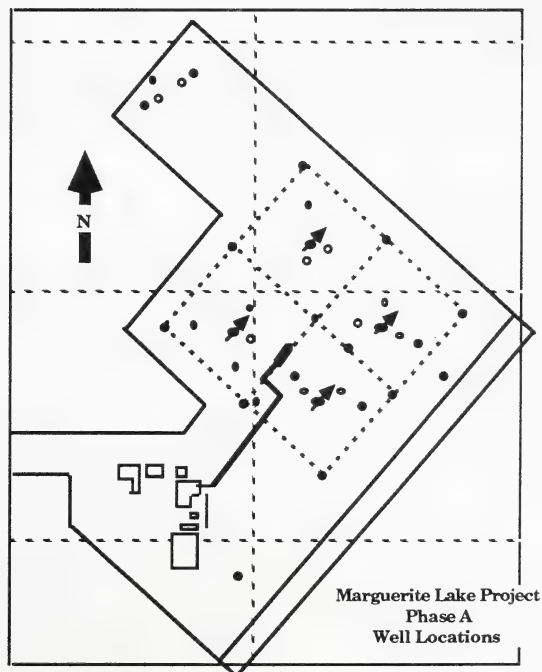
STORAGE FACILITIES: 3 - 499 m³ oil, 1 - 800 m³ water

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	Clearwater
Depth to Top of Formation:	440 m.KB
Reservoir Thickness:	
net:	23 m
gross:	35.4 m
Original Temperature:	16°C
Original Pressure:	2800 kPa
Average Horizontal Permeability:	1150 md
Average Porosity:	31%
Average Water Saturation	35%
Average Oil Saturation	65% pore volume
Oil Viscosity at Reservoir Temp.	100,000 mPa.s
Oil Gravity at Reservoir Temp.	993 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	AOSTRA

COMMENTS: This project terminated April 1, 1987. New Project (BP/PCI Project Owl) started on same location with new partner.



BP Canada/Petro-Canada Resources

Project Owl

LOCATION

LSD 8,9,16,5,12,13 Section: 7.9 Township: 66
Range: 5 W4M

PARTNERS:

Petro-Canada Resources 50%
BP Canada (Operator) 50%

PROCESS: Wet Combustion with O₂

COST:

Capital - \$1,000,000
Operating - \$7,000,000

START-UP: April 1987

TERMINATION: December 1988

DESCRIPTION

PILOT AREA: 20 ha over 4 patterns

WELL PATTERN: 4 5-Spot patterns with subsequent in-fill drilling

WELL SPACING: Initial 2 ha spacing

NO. OF WELLS:

Injection/Production 3 oxygen-water injectors, and 16 producers.

1 non-operational well 12 observation wells (12 for temperature only; 2 for temperature and pressure)

FACILITIES

STEAM GENERATOR(S): two - 53 GJ/hr

ARTIFICIAL LIFT METHODS: Standard Pump Jack

TREATER TYPE: 8' x 30' Cenatco

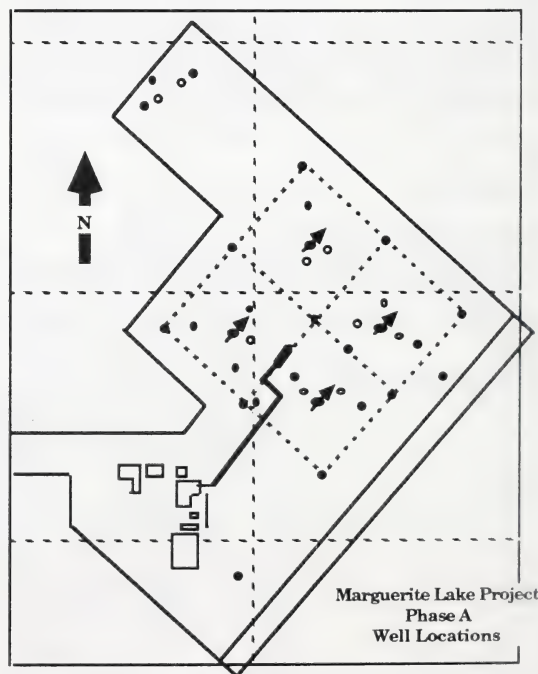
STORAGE FACILITIES: 3 - 499 m³ oil, 1 - 800 m³ water

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	Clearwater
Depth to Top of Formation:	440 m.KB
Reservoir Thickness:	
net:	23 m
gross:	35.4 m
Original Temperature:	16°C
Original Pressure:	2800 kPa
Average Horizontal Permeability:	1150 md
Average Porosity:	31%
Average Water Saturation	35%
Average Oil Saturation	65% pore volume
Oil Viscosity at Reservoir Temp.	100,000 mPa.s
Oil Gravity at Reservoir Temp.	993 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	Project Operator

COMMENTS: Combustion development continued at Wolf Lake.



Bumper Development Corporation Ltd.

Twining Rundle 'A' Pool

LOCATION

LSD 12 Section: 16 Township: 31 Range: 24 W4M

PARTNERS:

Bumper Development Corporation Ltd.
Enron Oil Canada Ltd.
AOSTRA

PROCESS: Re-completion of a Pekisko oil well by drilling a single horizontal drainhole.

COST: \$556,000

START-UP: October 1987

TERMINATION: January 1, 1992

DESCRIPTION

PILOT AREA: About 32 ha

WELL PATTERN: Single well

WELL SPACING: 32 ha

NO. OF WELLS:

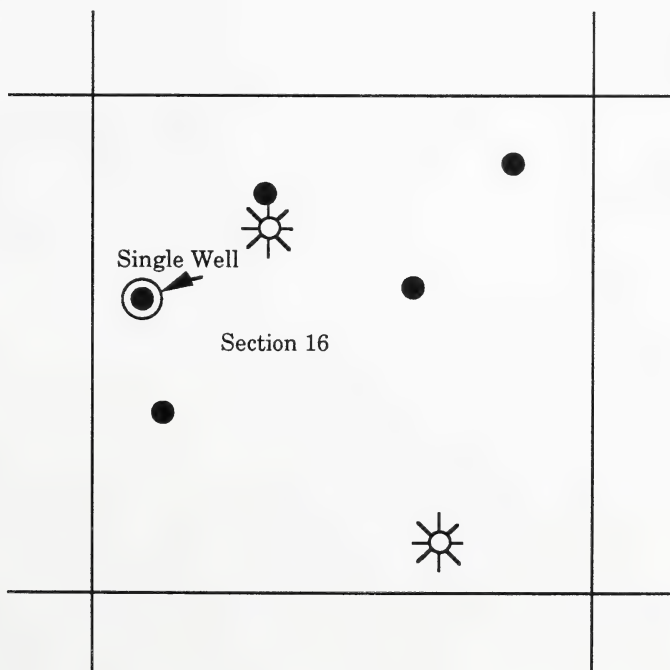
One production well only.

FACILITIES

ARTIFICIAL LIFT METHOD: Reciprocating sub-surface pump.

RESERVOIR

Producing Formation:	Pekisko of the Twining Rundle 'A' Pool
Depth to Top of Formation:	1660 m.KB
Reservoir Thickness:	
net:	15 m
gross:	40 m
Original Temperature:	61°C
Original Pressure:	11410 kPa
Average Horizontal Permeability:	5 md
Average Porosity:	5.7%
Average Water Saturation	36%
Average Oil Saturation	64%
Oil Viscosity at Reservoir Temperature	1.6 mPa.s
Oil Gravity at Reservoir Temp	876 Kg/m ³
Primary Production Rates:	1 m ³ /well/day
Source:	Pilot Operator



Canadian Hunter Exploration Ltd.

Swan Hills Beaverhill Lake

LOCATION

LSD 13 Section: 11 Township: 67 Range: 8 W4M

PARTNERS:

Canadian Hunter Exploration Ltd.	50%
AOSTRA	50%

PROCESS: Horizontal well recovery from a tight carbonate reservoir.

COST: \$1,500,000 drill (not completed)

START-UP: January 1988

TERMINATION: n/a

DESCRIPTION

PILOT AREA: Single well

WELL PATTERN: n/a

WELL SPACING: n/a

NO. OF WELLS: 1

FACILITIES

STEAM GENERATOR(S): n/a

ARTIFICIAL LIFT METHODS: Conventional rod pump and pump jack

TREATER TYPE: n/a

STORAGE FACILITIES: n/a

TRANSPORT: Truck fluid out.

RESERVOIR

Geological Horizon:	Swan Hills Beaverhill Lake Formation
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Depth to Top of Formation:	2268 m.KB
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Reservoir Thickness:	
net:	m
gross:	14 m

Original Temperature:	83.5°C
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Original Pressure:	21000 kPa
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Average Horizontal Permeability:	n/a md
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Average Porosity:	5%
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Average Water Saturation - S_w	14%
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Average Oil Saturation S_o	84% pore vol.
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Oil Viscosity at Reservoir Temperature	n/a mPa.s
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Oil Gravity at Surface Temp.	43°API
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Primary Production Rates:	n/a m ³ /well/day
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Source:	Pilot Operator
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Canada Northwest Energy Ltd.

Atlee - Buffalo

LOCATION

LSD ___ Section: 19,20&30 SW4M Township: 21
Range: 5 W4M

PARTNERS:

Hexagon Gas	31.9771%
Murphy Oil	10.1835%
Canada Northwest Energy Ltd.	57.8394%

PROCESS: Cyclic Steam

COST: Capital - Using existing wells and facilities

START-UP: February 1, 1986

TERMINATION: Unknown at present.

DESCRIPTION

PILOT AREA: n/a

WELL PATTERN: Conventional 40 acre spacing at present.

WELL SPACING: 40 acre spacing

NO. OF WELLS:

10 huff and puff existing

FACILITIES

STEAM GENERATOR(S): one - 23.2 GJ/hr

ARTIFICIAL LIFT METHODS: Pump Jacks

TREATER TYPE: Colt

STORAGE FACILITIES:

TRANSPORT: Truck to Bow River Terminal at Jenner

RESERVOIR

Geological Horizon:	Glauconite
Depth to Top of Formation:	892 m.KB
Reservoir Thickness:	
net:	10 m
gross:	10 m
Original Temperature:	26°C
Original Pressure:	10000 kPa
Average Horizontal Permeability:	2000 md
Average Porosity:	29%
Average Water Saturation S_w	23%
Average Oil Saturation S_o	77% pore vol.
Oil Viscosity at Reservoir Temp.	800 mPa.s
Oil Gravity at Reservoir Temp.	951 Kg/m ³
Primary Production Rates:	less than 5 m ³ /well/day
Source:	Pilot Operator

COMMENTS: Potential of steamflooding is being reviewed. Current reservoir pressure is too low to justify a large scale cyclic steam operation. The pilot project has been shut-in pending a resolution of an ownership problem.

Canadian Occidental Petroleum Ltd.

Manatokan Steam Project

LOCATION

LSD 1/2 Section: 13 Township: 63 Range: 8 W4M

PARTNERS:

Westcoast Petroleum Ltd. (Override royalty)

PROCESS: Huff'n puff/steam drive

COST: Capital \$25 MM

START-UP: December 1985

TERMINATION: December 1990 - currently suspended September 1988

DESCRIPTION

PILOT AREA: 48 ha (subsurface - pad drilling)

WELL PATTERN: 12 inverted 5-Spot patterns (4 ha spacing)

WELL SPACING: 2 ha

NO. OF WELLS:

Injection	32
Production	32
Observation	(+ 1 tentative) 1

Note: All wells are steamed then produced.

FACILITIES

STEAM GENERATOR(S): three - 52.76 GJ/hr steam generators

ARTIFICIAL LIFT METHODS: Slant hole conventional

TREATER TYPE: Heater treater and evaporator dehydrator (polishing unit)

STORAGE FACILITIES: four 63.5 m³ insulated tanks

TRANSPORT: Truck oil to Murphy Blackfoot truck terminal in Lloydminster area.

RESERVOIR

Geological Horizon:	Lower Grand Rapids Formation
Depth to Top of Formation:	370 m.KB
Reservoir Thickness:	
net:	12 m
gross:	22 m
Original Temperature:	20°C
Original Pressure:	3600 kPa
Average Horizontal Permeability:	1000 md
Average Porosity:	31%
Average Water Saturation - S _w	30%
Average Oil Saturation S _o	70% pore vol.
Oil Viscosity at Reservoir Temp.	90000 mPa.s
Oil Gravity at Reservoir Temp.	993 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	Pilot Operator

Canadian Occidental Petroleum Ltd.

Morgan

LOCATION

LSD 10 Section: 34 Township: 51 Range:4 W4M

PARTNERS:

Canadian Occidental Petroleum Ltd. 100%

PROCESS: Fireflood; ran on cyclic steam, currently on primary.

COST: Capital - \$8.2 million

START-UP: February 1986

TERMINATION: February 1991 - Steam suspended July 1988

DESCRIPTION

PILOT AREA: 16 ha

WELL PATTERN: 4, 4 ha inverted 5-Spots

WELL SPACING: 2 ha

NO. OF WELLS:

Injection	4
Production	9
Observation	0

FACILITIES

STEAM GENERATOR(S): one - 0.44 GJ/hr steam generator for pre-heat

ARTIFICIAL LIFT METHODS: Hydraulic pumping units; progressive cavity

TREATER TYPE: HTI (electronic) and Cold (distillation) polishing unit

STORAGE FACILITIES: 13 tanks (1684 m³ total capacity)

TRANSPORT: Husky's Cold Lake Heavy Oil Pipeline (tie-in on site)

RESERVOIR

Geological Horizon: Lloydminster Formation

Depth to Top of Formation: 570 TVD m.KB

Reservoir Thickness:

net: 7 TVD m

gross: 11 TVD m

Original Temperature: 23°C

Original Pressure: 3200 kPa

Average Horizontal Permeability: 3000 md

Average Porosity: 28%

Average Water Saturation - S_w 25%

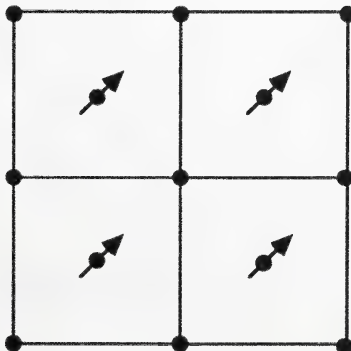
Average Oil Saturation S_o 75% pore vol.

Oil Viscosity at Reservoir Temp. 4600 mPa.s

Oil Gravity at Reservoir Temp. 988 Kg/m³

Primary Production Rates: 2.0 m³/well/day

Source: Pilot Operator



Chevron Canada Resources Ltd.

Taber

LOCATION

ELD 9 Section: 18 Township: 9 Range: 16 W4M

PARTNERS:

Lonlife Resources	5.9%
Anadarko	4.3%
Koch Exploration	2.8%
Norcen Energy Ltd.	1.7%
Other	2.6%

PROCESS: Polymer Flood

COST:

Capital - \$1.3 Million

Operating - \$1.15 Million/year

START-UP: June 1987 (commenced continuous polymer injection)

TERMINATION: 1994

DESCRIPTION

PILOT AREA: 194 ha

WELL PATTERN: Irregular pattern

WELL SPACING: 16 ha

NO. OF WELLS:

Injection	2
Production	7
Observation	0

FACILITIES

ARTIFICIAL LIFT METHODS: 5 Pump Jacks, 1 electrical sub pump, 1 pump progressing cavity

TREATMENT TYPE: C.E. NATCO - dual polarity

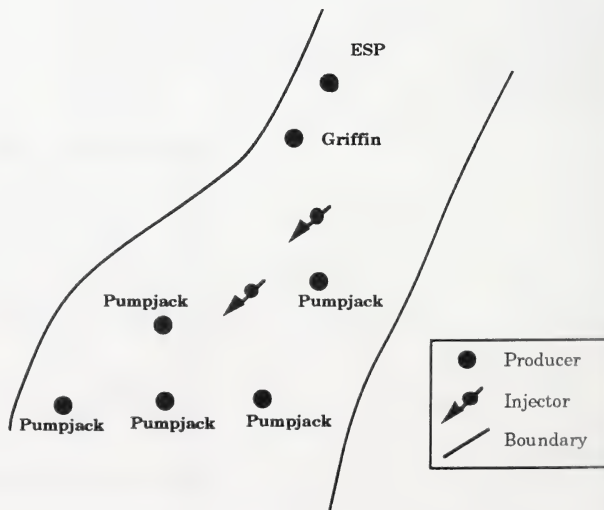
STORAGE FACILITIES: 2 - 80 m³ tanks

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon:	Upper Mannville
	Glauconitic Sandstone
Depth to Top of Formation:	971 m.KB
Reservoir Thickness:	
net:	81 m
gross:	9.0 m
Original Temperature:	35°C
Original Pressure:	10170 kPa
Average Horizontal Permeability:	1140 md
Average Porosity:	22.3%
Average Initial Water Saturation S_w	25%
Average Oil Saturation S_o	initial 75% pore vol.
	current 49.4% pore vol.
Oil Viscosity at Reservoir Temp.	55 mPa.s
Oil Gravity at Reservoir Temp.	900 Kg/m ³
Primary Production Rates:	Max. 25 m ³ /well/day
	Avg. 7 m ³ /well/day
Source:	Chevron

COMMENTS: Polymer slug is tapered during last 4 years. The scheme is classified as experimental and encompasses 2/3 of the entire pool in unit 1. Note: The pilot is still operating.



CS Resources

Pelican

LOCATION

LSD ____ Section: 3-17 Township: 81 Range: 22
W4M

PARTNERS:

C.S. Resources Ltd 100%
Deuvan Petroleum Ltd.

PROCESS: Primary Production only

COST: N/A

START-UP: 1980 Primary, 1981-1986 Fireflood,
1983-Present Cyclic Steaming

TERMINATION: Pilot Terminated May 1989

DESCRIPTION

PILOT AREA: Post-Combustion Primary, Water and
Steam Flood

WELL PATTERN: 9 Inverted 30 Acre 17 Spot
Patterns

OUTER PILOT AREA: Primary, Cyclic Steaming,
Horizontal wells

WELL PATTERN: Single Wells

WELL SPACING: See Above

NO. OF WELLS:

13 Vertical Wells

8 Horizontal Wells

FACILITIES

STEAM GENERATOR:

ARTIFICIAL LIFT METHODS: Lufkin, Griffin, Corod,
EMIP

TREATER TYPE: Atmospheric

STORAGE FACILITIES:

Single Wells - 750 BBI Tanks

Others - Group/Test Tanks

TRANSPORT:

Pilot - Underground to treating facilities

Outer Area - Tank Trucks

RESERVOIR

Geological Horizon: Wabiskaw - McMurray

Depth to Top of Formation: 400 m.KB

Reservoir Thickness:
net: 3.5-6.5 m

gross: 6.5 m

Original Temperature: 18°C

Original Pressure: 2375 kPa

Average Horizontal Permeability: 1000 md

Average Porosity: 26%

Average Water Saturation - S_w 30%

Average Oil Saturation S_o 70% pore volume

Oil Viscosity at Reservoir Temp. 800-1200 mPa.s

Oil Gravity at Reservoir Temp. 973 Kg/m³

Primary Production Rates: 2.8 m³/well/day
Source: Pilot Operator

COMMENTS: In Mid-1989, Gulf Canada Resources transferred its 100% ownership in the "Pelican project to C.S. Resources of Calgary. Prior to the transfer, Gulf abandoned the fireflood project and the majority of the single well installations. C.S. Resources retained 12 single wells and the 8 horizontal wells as well as the treating facilities. C.S. Resources have continued to operate the retained facilities in primary production mode only.

Esso Resources Canada Ltd.

Fisher Creek

LOCATION

LSD 3 Section: 1 Township: 67 Range: 6 W4M

PARTNERS:

Esso Farm in on AEC lands.

PROCESS: Cyclic Steam Stimulation

COST:

Capital - \$1.3 Million (10 km perm. access road) +
\$0.5 Million (facilities)

Operating - \$0.8 Million (Rental, trucking, etc.)

START-UP: 1986

TERMINATION: Currently on hold, pending
completion of production/injection data study.

DESCRIPTION

PILOT AREA:

WELL PATTERN: Single well pilot.

WELL SPACING: n/a

NO. OF WELLS:

Injection/Production - single well pilot

FACILITIES

STEAM GENERATOR(S): Portable equipment used,
currently not on site. 31.7 GJ/hr.

ARTIFICIAL LIFT METHODS: Pump-jack 4w co-rod
etc.

TREATER TYPE: Atmospheric Treater

STORAGE FACILITIES: Tank Farm

TRANSPORT: Truck - all fluids

RESERVOIR

Geological Horizon: Clearwater

Depth to Top of Formation: 460 m.KB

Reservoir Thickness:

net: m

gross: 15-50 m

Original Temperature: 15°C

Original Pressure: 3000 kPa

Average Horizontal Permeability: 700 md

Average Porosity: 29%

Average Water Saturation S_w 0.54-0.68%

Average Oil Saturation S_o 0.46-0.32% pore vol.

Oil Viscosity at Res. Temp. 30000-100000 mPa.s

Oil Gravity at Reservoir Temp. 980 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator

COMMENTS: Operations suspended August,
1986. Analysis followed and a report was issued
February, 1988. No further work is planned at this
time.

Esso Resources Canada Ltd.

Leduc

LOCATION

LSD 8 Section: 17 Township: 50 Range: 26 W4M

PARTNERS:

Esso Resources Canada Ltd.

Leduc Woodbend D-2 Unit

PROCESS: Hydro carbon miscible flood (propane) following brine pre-flush

COST: n/a

START-UP: September 1985

TERMINATION: May 1988

DESCRIPTION

WELL SPACING: See plot plan

NO. OF WELLS:

Injection	1
Production	1
Observation	1

FACILITIES

ARTIFICIAL LIFT METHODS: Rod Pump

TREATER TYPE: 3 phase separator

STORAGE FACILITIES: Brine & Propane tanks for Injection

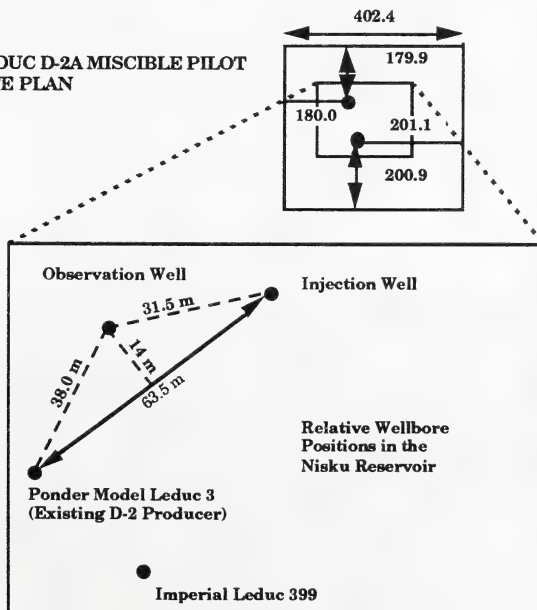
TRANSPORT: Injected fluids are trucked. Produced fluids are transported through existing flowlines.

RESERVOIR

Geological Horizon:	Nisku
Depth to Top of Formation:	1550 m.KB
Reservoir Thickness:	
net:	n/a m
gross:	45 m
Original Temperature:	63°C
Original Pressure:	12300 kPa
Average Horizontal Permeability:	10 md
Average Porosity:	3.7%
Average Water Saturation S_w	26%
Average Oil Saturation S_o	34% pore vol.
Oil Viscosity at Reservoir Temp.	0.6 mPa.s
Oil Gravity at Reservoir Temp.	730 Kg/m ³
Primary Production Rates:	30 m ³ /well/day
Source:	Pilot Operator

COMMENTS: The pilot is located at 8-17-50-26 W4M and consists of an injector producer pair. One observation well was drilled in October, 1987 and a sponge core taken. The oil saturation was measured by interwell tracer, sponge core and single well tracer. All three methods yielded the same answer.

LEDUC D-2A MISCIBLE PILOT
SITE PLAN



Esso Resources Canada Ltd.

Leming

LOCATION

LSD ___ Section: 4-8 Township: 65 Range: 3 W4M

PARTNERS:

Esso Resources Canada Ltd.

100%

PROCESS: Cyclic Steam Stimulation,
Displacement, Horizontal Wells

COST: Capital - \$227 Million

START-UP: January 1975

TERMINATION: On going

5 - 42.3 GJ/hr. (Fresh water)

Generator ratings are based on heat input to the water.

ARTIFICIAL LIFT METHODS: Pump Jacks, Hydro-beam, HEP

TREATER TYPE: Electro Static Grid (NATCO)

STORAGE FACILITIES: Tankage

TRANSPORT: Pipeline

RESERVOIR

DESCRIPTION

PILOT AREA: 1295 ha

WELL PATTERN: Various cluster patterns - see diagram

WELL SPACING: 0.7, 0.8, 0.94, 1.6, 2.9 ha

NO. OF WELLS:

Injection/Production

496

Observation

55

Geological Horizon:

Clearwater

Depth to Top of Formation:

440 m.KB

Reservoir Thickness:

net:

45 m

gross:

50 m

Original Temperature:

13°C

Original Pressure:

3100 kPa

Average Horizontal Permeability:

1500 md

Average Porosity:

35%

Average Water Saturation - S_w

30%

Average Oil Saturation S_o

70% pore vol.

Oil Viscosity at Reservoir Temp.

100000 mPa.s

Oil Gravity at Reservoir Temp.

995 Kg/m³

Primary Production Rates:

nil m³/well/day

Source:

Pilot Operator

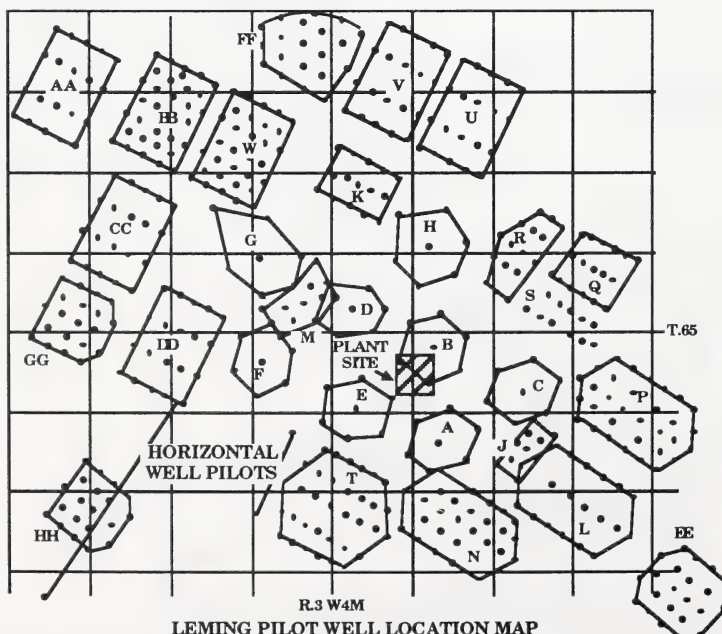
FACILITIES

STEAM GENERATOR(S):

2 - 137.3 GJ/hr. (Produced water)

1 - 156.3 GJ/hr. (Fresh water)

2 - 52.75 GJ/hr. (Fresh water)



LEMING PILOT WELL LOCATION MAP

Esso Resources Canada Ltd.

May/Ethel

LOCATION

LSD ____ Section: 22,27,28 Township: 64 Range:
3 W4M

PARTNERS:

Esso Resources Canada Ltd. 100%

PROCESS: Cyclic Steam Stimulation and
Displacement

COST: Capital - \$70 Million

START-UP: May - 1972

Ethel - 1964 (Abandoned)

TERMINATION: Ongoing

DESCRIPTION

PILOT AREA: 777 ha

WELL PATTERN: See Diagram

WELL SPACING: 1 and 2 ha

NO. OF WELLS:

Injection/Production

106

Observation

8

FACILITIES

STEAM GENERATOR(S): 4 - 52.75 GJ/hr, 1 26.00
GJ/hr, 1 - 10.60 GJ/hr

ARTIFICIAL LIFT METHODS: Standard Pump Jacks

TREATER TYPE: Electrostatic Grid (NATCO)

STORAGE FACILITIES: Tankage

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon: Clearwater

Depth to Top of Formation: 440 m.KB

Reservoir Thickness:

net: 45 m

gross: 55 m

Original Temperature: 13°C

Original Pressure: 3033 kPa

Average Horizontal Permeability: 1500 md

Average Porosity: 35%

Average Water Saturation - S_w 30%

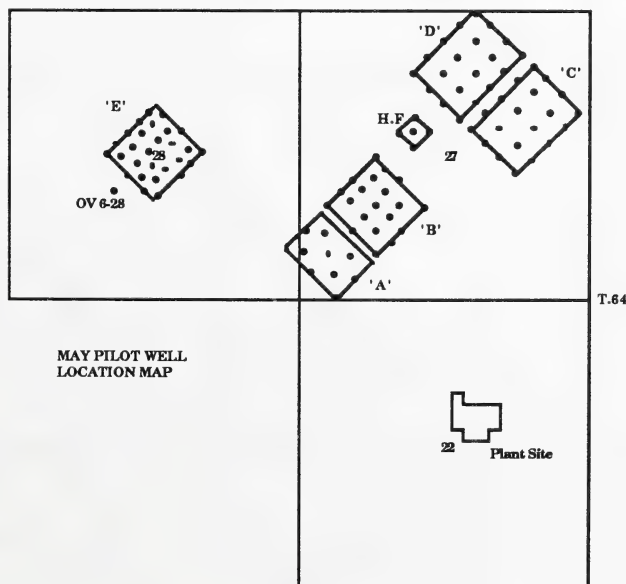
Average Oil Saturation S_o 70% pore vol.

Oil Viscosity at Reservoir Temp. 100000 mPa.s

Oil Gravity at Reservoir Temp. 95 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator



R.3 W.4M

Esso Resources Canada Ltd.

Rainbow

LOCATION

LSD 3 Section: 11 Township: 110 Range: 7 W6M

PARTNERS:

Esso Resources Canada Limited 100%

PROCESS: Drainhole in bottom water drive pool.

COST:

Capital: 1.32 M\$

Operating: 30 K\$/year

START-UP: April 9, 1987

TERMINATION: None

DESCRIPTION

PILOT AREA: 65 ha

WELL PATTERN: N/A

NO. OF WELLS:

Injection	0
Production	1
Observation	0

FACILITIES

ARTIFICIAL LIFT METHODS: Pump Jack

RESERVOIR

Geological Horizon: Keg River

Depth to Top of Formation: 1,670 m.KB

Reservoir Thickness:

net: 19.6 m

gross: 23 m

Original Temperature: 84°C

Original Pressure: 15,620 kPa

Average Horizontal Permeability: 200 md

Average Porosity: 4.5%

Average Water Saturation S_w 22%

Average Oil Saturation S_o 78% pore volume

Oil Viscosity at Reservoir Temp. n/a mPa.s

Oil Gravity at Reservoir Temp. 797 Kg/m³

Primary Production Rates: 60 m³/well/day

Source: Pilot Operator

Esso Resources Canada Ltd.

Redwater

LOCATION

LSD All Section: 29 Township: 57 Range: 21 W4M
LSD 4,5,12&13 Section: 28 Township: 57 Range: 21 W4M
LSD 1,2,3,4 Section: 32 Township: 57 Range: 21 W4M
LSD 4 Section: 33 Township: 57 Range: 21 W4M

PARTNERS:

Esso Resources Canada Ltd. 100%

PROCESS: Enriched Hydrocarbon Miscible Flood

COST: (Cumulative to date)

Capital - \$4.8 Million

Operating - \$13.1 Million

START-UP: January 1985

TERMINATION: January 1994

DESCRIPTION

PILOT AREA: 404.7 ha

WELL PATTERN: 4 inverted 5-spot injection patterns

WELL SPACING: 8.094 ha

PATTERN SPACING: 16.2 ha

NO. OF WELLS:

Injection	4
Production (in the injection patterns)	9
16 producers to contain the injection patterns	

FACILITIES

One gas compressor: 28,000 m³/d @ 9.7 MPa capacity

ARTIFICIAL LIFT METHODS: Electric Submersible pumps

TRANSPORT: NGL Pipeline

RESERVOIR

Geological Horizon: Upper Devonian Leduc D3

Depth to Top of Formation: 903 m.KB

Reservoir Thickness:

net: 31.39 m

gross: m

Original Temperature: 34.6°C

Original Pressure: 7450 kPa

Average Horizontal Perm.: 40-200 (Foreslope) md

100-1500 (Backreef) md

Average Porosity: 6%(Backreef)

12% (Foreslope)

Average Water Saturation S_w 25%

Average Oil Saturation S_o 75% pore vol.

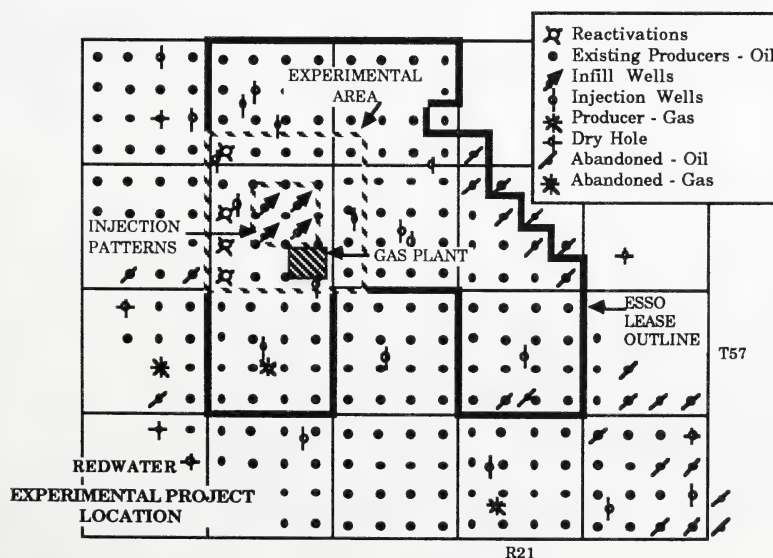
Oil Viscosity at Reservoir Temp. 2.7 mPa.s

Oil Gravity at Reservoir Temp. 844 Kg/m³

Primary Production Rates: 1-8 m³/well/day

Source: Pilot Operator

COMMENTS: The first pattern was flooded beginning October, 1987 for approximately 6 months. The second pattern was flooded in the first half of 1989. Solvent injection into the third and fourth patterns is scheduled for mid 1990 and 1991 respectively. Chase gas injection into all four patterns will follow completion of solvent injection.



Excel Energy Inc.

Excel Ardmore

LOCATION

LSD 11,12,13,14 Section: 20 Township: 62 Range:
3 W4M

PARTNERS:

Excel Energy Inc.	65%
Koch Exploration Ltd.	35%

PROCESS: Steam Stimulation/Steam Drive

COST: Operating: \$45,000/month

START-UP: September 1, 1975

TERMINATION: July 1, 1989

DESCRIPTION

PILOT AREA: 32.4 ha

WELL PATTERN: 5-Spot pattern

WELL SPACING: 1.02 ha and 2.04 ha/well

NO. OF WELLS:

Injection/Production	18
Water disposal	1

FACILITIES

STEAM GENERATOR(S): one - 26 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Conventional Pump Jacks

TREATER TYPE: Atmospheric

STORAGE FACILITIES: Tanks

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	Clearwater
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Depth to Top of Formation:	375 m.KB
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Reservoir Thickness:	
net:	15 m
gross:	40 m

Original Temperature:	15°C
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Original Pressure:	2000 kPa
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Average Horizontal Permeability:	1500 md
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Average Porosity:	30%
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Average Water Saturation S_w	30%
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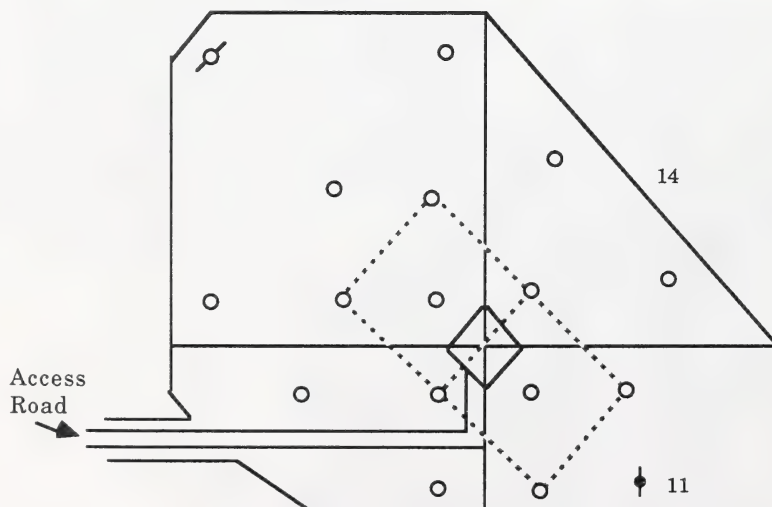
Average Oil Saturation S_o	70% pore volume
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Oil Viscosity at Reservoir Temp.	500,000 mPa.s
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Oil Gravity at Reservoir Temp.	1,000 Kg/m ³
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Primary Production Rates:	nil m ³ /well/day
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Source:	Pilot Operator
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Gulf Canada Resources Ltd.

Fenn-Big Valley

LOCATION

LSD 2 Section: 23 Township: 35 Range: 20 W4M

PARTNERS:

Gulf Canada Resources Ltd.
AOSTRA

PROCESS: Nitrogen Injection

COST: \$1.6 MM (est.)

START-UP: July 16, 1987

TERMINATION: September 1988 (nitrogen injection)

DESCRIPTION

PILOT AREA: Approximately 30 ha

WELL PATTERN:

The Experimental Scheme is planned and directed toward field testing of two processes never before applied in Alberta:

- (a) improved recovery of oil, NGL's and sulphur from a Devonian carbonate reef with nitrogen.
- (b) control of fluid interfaces within a Devonian carbonate reef by the injection of nitrogen to optimize oil recovery by an immiscible process.

WELL SPACING: 16 ha

NO. OF WELLS:

Injection	1
Production	1

FACILITIES

STEAM GENERATOR(S): N/A

ARTIFICIAL LIFT METHODS: Bottom hole pump until 88-02, flowing thereafter

TREATER TYPE: None (Wellhead Separator)

STORAGE FACILITIES: N/A

TRANSPORT: Satellite gathering system.

RESERVOIR

Geological Horizon:	Leduc (D-3)
Depth to Top of Formation:	1644.1 m.KB
Reservoir Thickness:	
net:	3.81 m
gross:	4.00 m
Original Temperature:	59°C
Original Pressure:	12,510 kPa
Average Horizontal Permeability:	800 (est.) md
Average Porosity:	8.5%
Average Water Saturation S_w	15%
Average Oil Saturation S_o	85% pore volume
Oil Viscosity at Reservoir Temp.	0.8 mPa.s
Oil Gravity at Reservoir Temp.	876 Kg/m ³
Primary Production Rates:	9.0 m ³ /well/day
Source:	ERCB ST87-18 and Gulf

Home Oil Company Ltd.

Lloydminster (Kitscoty)

LOCATION

LSD 2,3,4 Section: 2 Township: 51 Range: 2 W4M

PARTNERS:

Esso Canada Resources Ltd.

17.5%

Home Oil Company Ltd.

82.5%

PROCESS: Cyclic Steam and Steamflood

COST:

Capital - 9×10^6 or \$10,000,000 for Phase I, II and III
(5 new wells were drilled in 1988 and an existing well was tied to the project).

Operating - N/A

START-UP: 1981

TERMINATION: 1992

DESCRIPTION

WELL PATTERN: One five spot and two six spot and 2 single Huff and Puff wells

WELL SPACING: 2 ha

NO. OF WELLS:

All 15 wells are still on cyclic.

FACILITIES

STEAM GENERATOR(S): one - 26.37 GJ/hr steam generator

STORAGE FACILITIES: Tanks

TRANSPORT: Trucks

RESERVOIR

Geological Horizon: Sparky Sand

Depth to Top of Formation: 570 m.KB

Reservoir Thickness:

net: 19 m

gross: 26 m

Original Temperature: 15°C

Original Pressure: 3400 kPa

Average Horizontal Permeability: 2000-3000 md

Average Porosity: 30%

Average Water Saturation S_w 20%

Average Oil Saturation S_o 80% pore volume

Oil Viscosity at Reservoir Temp. 8000 mPa.s

Oil Gravity at Reservoir Temp. 985 Kg/m³

Primary Production Rates: 5 m³/well/day

Source: Pilot Operator

COMMENTS:

Home Oil drilled 5 new wells in 1988 and tied an existing well to the project.



Husky Oil Ltd.

Caribou Lake Pilot Project

LOCATION

LSD ____ Section: 12 Township: 69 Range: 5 W4M

PARTNERS:

Husky Oil Ltd.

AEC Oil & Gas Company

PROCESS: Cyclic Steam Stimulation

COST: \$20 Million

START-UP: December 1990

TERMINATION: Ongoing

DESCRIPTION

PILOT AREA: 40 ha

WELL PATTERN: elongated, inverted 7-spot

WELL SPACING: 1.6 ha/well

NO. OF WELLS: 25 injection/production wells

FACILITIES

STEAM GENERATOR(S): 1-50 MMBTU/hr

1-25 MMBTU/hr

ARTIFICIAL LIFT METHODS: Conventional Pump Jacks

TREATER TYPE: Horizontal, 3 phase, electrostatic

STORAGE FACILITIES: Lease Tanks

TRANSPORT: Trucking

RESERVOIR

Geological Horizon: Clearwater B

Depth to Top of Formation: 450 m.KB

Reservoir Thickness:
net: 22 m

gross: 25 m

Original Temperature: 16°C

Original Pressure: 2800 kPa

Average Horizontal Permeability: 1500 md

Average Porosity: 33%

Average Water Saturation S_w : 40%

Average Oil Saturation S_o : 60% pore volume

Oil Viscosity at Reservoir Temp. 33,000-69,000 mPa.s

Oil Gravity at Reservoir Temp. 990 Kg/m³

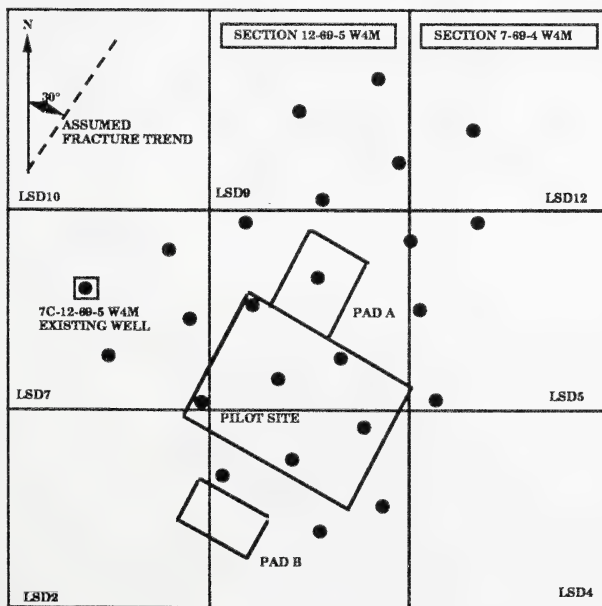
Primary Production Rates: nil m³/well/day

Source: Pilot Operator

COMMENTS: Husky Oil Ltd. and AEC Oil & Gas Company announced their intention to proceed with the development of the Caribou Lake Pilot Project, located in Township 69, Range 5 @4M, in the Cold Lake Air Weapons Range. This project will test the potential commercial application of producing heavy oil using cyclic steaming technology. Husky will operate the project and has a 60% working interest. AEC Oil & Gas Company, A Division of Alberta Energy Company Ltd., has a 40% working interest in the project.

Husky and AEC have drilled 48 exploratory and development wells on the 372-section Caribou Lake block. Natural gas and bitumen discoveries have resulted, with the quality and extent of the bitumen resources justifying this pilot recovery project.

Site clearing and preparation is to start immediately with well drilling to follow after freeze-up and the main facility construction to occur through the second and third quarters of 1990, followed by start-up prior to year-end. The pilot will consist of 25 cyclic steam/production wells, 75 MMBTU/hour steam generation capacity and associated oil treating and produced water clarification facilities. A comprehensive testing and analysis program to define technology for maximum reuse of produced water will be incorporated. Total capital cost of the Pilot is expected to be approximately \$20 million.



HUSKY OIL OPERATIONS LTD.
Caribou Lake Pilot

LEGEND

● PILOT WELLS

Husky Oil Operations Ltd.

Kearl Lake

LOCATION

LSD ____ Section: 9,10,15,16 Township: 95
Range: 7 W4M

PARTNERS:

*Husky Oil Operations Ltd.	38.25%
Esso Resources Canada Limited	36.75%
AOSTRA	25%

* Husky Oil Operations Ltd. acts as agent for
Canterra Energy Ltd.

PROCESS: Modified Steam Drive

COST:

Capital - \$54,000,000

Operating - \$73,000,000

START-UP: 1981

TERMINATION: n/a

RESERVOIR

Producing Formation:	McMurray
Depth to Top of Formation:	150 m.KB
Reservoir Thickness:	
net:	40 m
gross:	75 m
Original Temperature:	10°C
Original Pressure:	800 kPa
Average Horizontal Permeability:	2000-6000 md
Average Porosity:	32%
Average Water Saturation	24%
Average Oil Saturation	76%
Oil Viscosity at Reservoir Temp.	2.0 x 10 ⁶ mPa.s
Oil Gravity at Reservoir Temp.	1014 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	Pilot Operator

DESCRIPTION

PILOT AREA: "A" Pattern 6.4 ha; B Pattern 3.24 ha
WELL PATTERN:

WELL SPACING: "A" Pattern 0.71 ha; BI1 Pattern
0.27 ha; BI8 & BI9 Patterns 0.54 ha.

NO. OF WELLS:

	"A" Pattern	"B" Pattern
Injection (steam)	7 (7 suspended)	3
Production	6 (3 suspended)	12
Observation	9 (3 suspended)	14

FACILITIES

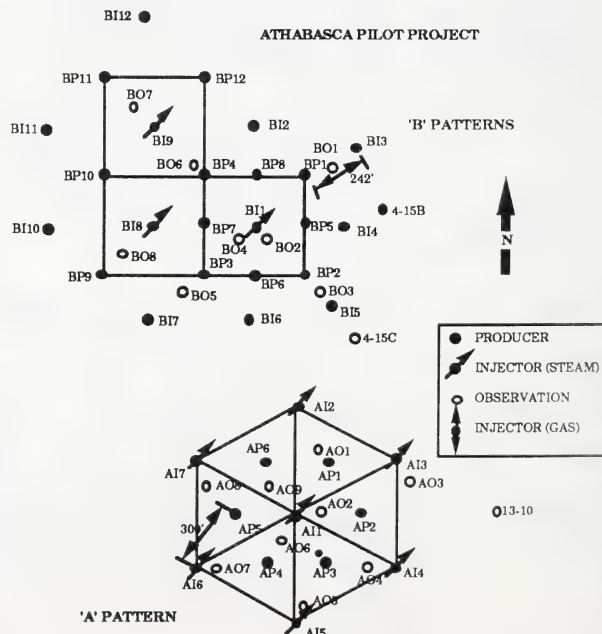
STEAM GENERATORS: Three 53 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Conventional rod insert pumps.

TREATER TYPE: Field separators and pressure treaters at central facility.

STORAGE FACILITIES: Heated tanks.

TRANSPORT: Trucks.



Koch Exploration Canada Ltd.

Fort Kent

LOCATION

LSD 11 Section: 19 Township: 61 Range: 4 W4M

PARTNERS:

Koch Exploration Canada Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST: N/A

START-UP: December 13, 1985

TERMINATION: N/A

DESCRIPTION

PILOT AREA: 65 ha

WELL SPACING: 2.02 ha

NO. OF WELLS:

Injection/Production (slant) 13

Water Disposal Well 1

Water Source Well 1

FACILITIES

STEAM GENERATOR(S): one - 31.65 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Bottom Hole Pump

TREATER TYPE: FWKO & Electrostatic Treater

STORAGE FACILITIES: Tanks

TRANSPORT: Husky Pipeline to Lloydminster

RESERVOIR

Geological Horizon: Upper Grand Rapids

Depth to Top of Formation: 345 m.KB

Reservoir Thickness:

net: 15 m

gross: 17 m

Original Temperature: 21°C

Original Pressure: 3500 kPa

Average Horizontal Permeability: 2000 md

Average Porosity: 35%

Average Water Saturation S_w 30%

Average Oil Saturation S_o 70% pore volume

Oil Viscosity at Reservoir Temp. 30,000 mPa.s

Oil Gravity at Reservoir Temp. 992 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator

Mazzei Oil & Gas Ltd.

Frog Lake

LOCATION

Section: 15 Township: 56 Range: 3 W4M

PARTNERS:

Mazzei Oil & Gas Ltd. 100%

PROCESS: Compare Huff and Puff Steam to Electromagnetic

COST: \$1 Million

START-UP: February 1, 1990

TERMINATION: March 1993

DESCRIPTION

PILOT AREA: Frog Lake

WELL PATTERN:

WELL SPACING: 40 acre

NO. OF WELLS: 4 wells being tested 2 Steam and 2 Electromagnetic

FACILITIES

STEAM GENERATOR(S): 25 mill steam generator

ARTIFICIAL LIFT METHODS: Tubing Pump

TREATER TYPE:

STORAGE FACILITIES:

TRANSPORT: Truck oil to Murphy Blackfoot

RESERVOIR

Geological Horizon: G.P. and Sparky Zones

Depth to Top of Formation: 457 m.KB

Reservoir Thickness:
net: 3.0 m
gross: 3.5 m

Original Temperature: 25°C

Original Pressure: kPa

Average Horizontal Permeability: md

Average Porosity: 33%

Average Water Saturation S_w 15%

Average Oil Saturation S_o % pore volume

Oil Viscosity at Reservoir Temp. mPa.s

Oil Gravity at Reservoir Temp. 10 Kg/m³

Primary Production Rates: 7 m³/well/day

Source: Pilot Operator

COMMENTS: First cycle of steam requires 2000 m³ slug. Second cycles requires 3000 m³ slug.

Mobil Oil Canada, Ltd.

Iron River Pilot

LOCATION

LSD 11, 12, 13, 14 Section: 6 Township: 64
Range: 4 W4M

PARTNERS:

Mobil Oil Canada, Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST: \$14 Million

START-UP: March 15, 1988

TERMINATION: Approval Expires April 30, 1992

DESCRIPTION

PILOT AREA: 160 acres

WELL PATTERN: See diagram

WELL SPACING: 4 acre; 8 acre

NO. OF WELLS:

Injectors/Producers 23

Observation Wells 3

FACILITIES

STEAM GENERATOR(S): two - 26 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Slant and Conventional Pump Jacks, progressive cavity pumps, chamber pumps

TREATER TYPE: Production flowlined to nearby Iron River Battery, with on site treating and water disposal employing a pressure treater.

STORAGE FACILITIES:

TRANSPORT: Clean oil is trucked to Husky Tucker Lake terminal.

RESERVOIR

Geological Horizon: Lower Grand Rapids (Sparky)

Depth to Top of Formation: 360 m.KB

Reservoir Thickness:

net: 19 m

gross: 27 m

Original Temperature: 15°C

Original Pressure: 3000 kPa

Average Horizontal Permeability: 500-2000 md

Average Porosity: 35%

Average Water Saturation S_w 35%

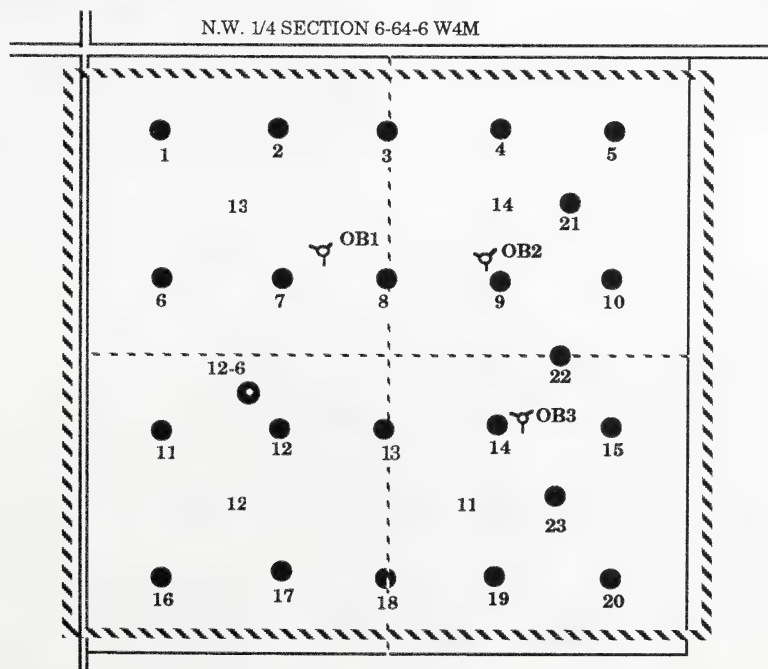
Average Oil Saturation S_o 65% pore volume

Oil Viscosity at Reservoir Temp. 50,000 mPa.s

Oil Gravity at Reservoir Temp. 988 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator



Mobil Oil Canada, Ltd.

Kitscoty

LOCATION

LSD ____ Section: 7, 18, 12, 13 & 14 Township: 51

Range: 2 W4M

PARTNERS:

Mobil Oil Canada, Ltd.

Norcen Energy Resources Ltd.

Home Oil Company Ltd.

PROCESS: Thermal drive with water slug.

COST: N/A

START-UP: September 1975

TERMINATION: December 1988

DESCRIPTION

PILOT AREA: 420.9 ha

WELL PATTERN: Inverted 7-Spots

WELL SPACING: 4.05 ha

NO. OF WELLS:

Injection	7
Production	84
Observation	2

FACILITIES

STEAM GENERATOR(S): one air compressor 90.6
 $\times 10^3 \text{ m}^3/\text{d}$ @ 6.895 MPa

ARTIFICIAL LIFT METHODS: Standard Pump Jacks
with some Griffin downhole pumps.

TREATER TYPE: Pressure Treater

STORAGE FACILITIES: Lease tanks and central
treating receiving tanks.

TRANSPORT: Husky Pipeline

RESERVOIR

Geological Horizon: Sparky Sand

Depth to Top of Formation: 548 m.KB

Reservoir Thickness:

net: 5 m

gross: m

Original Temperature: 21°C

Original Pressure: 3450 kPa

Average Horizontal Permeability: 2000 md

Average Porosity: 34%

Average Water Saturation S_w 15%

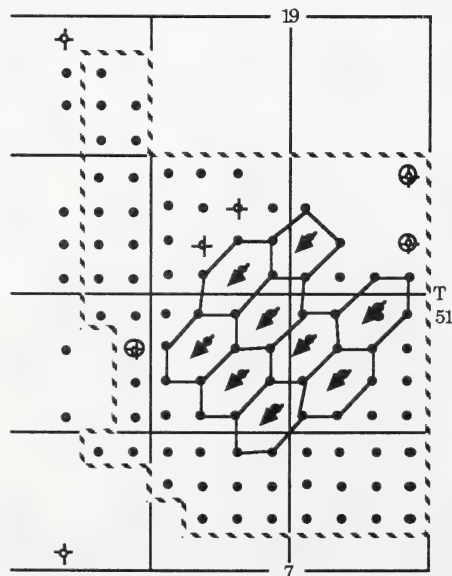
Average Oil Saturation S_o 85% pore volume

Oil Viscosity at Res. Temp. 15,000-40,000 mPa.s

Oil Gravity at Reservoir Temp. 985 Kg/m^3

Primary Production Rates: 1-2 $\text{m}^3/\text{well}/\text{day}$

Source: Pilot Operator



Mobil Oil Canada, Ltd.

Wolf Lake

LOCATION

LSD ____ Section: 5, 6, 7, 8 Township: 64 Range:
6 W4M Also: 21, 27-64-6, 12-64-7, 31, 32-63-6 and
36-63-7

PARTNERS:

Mobil Oil Canada, Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST: N/A

START-UP: May 1982; Several tests added

TERMINATION:

DESCRIPTION

PILOT AREA: Widely spaced wells.

WELL PATTERN: Individual well steam stimulations

NO. OF WELLS:

Injection/Production 15

Observation 1

(Nine wells currently suspended.)

FACILITIES

STEAM GENERATOR(S): one portable 26 GJ/hr

ARTIFICIAL LIFT METHODS: Conventional tubing pumps.

TREATER TYPE: Produced to wellhead tanks and trucked to recently completed on-site treating and water disposal facilities employing a pressure treater. Clean oil is trucked to the Husky sales terminal at Tucker

STORAGE FACILITIES:

TRANSPORT: Trucked

RESERVOIR

Geological Horizon: Upper & Lower Grand Rapids

Depth to Top of Formation: UGR 310-350 m.KB
LGR 340-380 m.KB

Reservoir Thickness:

net: UGR 0-10 m

LGR 10-30 m

gross: UGR 20-60 m

LGR 60-80 m

Original Temperature: 15°C

Original Pressure: 3200 kPa

Average Horizontal Permeability: 1000-4000 md

Average Porosity: 35%

Average Water Saturation S_w 38%

Average Oil Saturation S_o 62% pore volume

Oil Viscosity at Res. Temp. 20,000-100,000 mPa.s

Oil Gravity at Reservoir Temp. 1000-986 Kg/m³
(10-12°API)

Primary Production Rates: nil m³/well/day

Source: Pilot Operator

Mobil Oil Canada, Ltd.

Wolf Lake Extension

LOCATION

LSD 11 Section: 17 Township: 64 Range: 6 W4M

PARTNERS:

Mobil Oil Canada, Ltd. 100%

PROCESS: Horizontal well-steam stimulated

COST: N/A

START-UP: June 15, 1989

TERMINATION:

DESCRIPTION

Horizontal well - steam stimulated - with 3 vertical temperature observation wells.

PILOT AREA: ~3 ha

WELL PATTERN: single horizontal well - 300 m

WELL SPACING: n/a

NO. OF WELLS: 4-1 horizontal, 3 vertical

FACILITIES

STEAM GENERATOR(S): 1 - 26 GJ/hr

ARTIFICIAL LIFT METHODS: steam circulation/beam pump

TREATER TYPE: Atmospheric gravity segregation on-site.

STORAGE FACILITIES: 6 - tanks (120 m³) on site

TRANSPORT: Trucked to Iron River Facility for treating prior to trucking to Husky Tucker Lake terminal.

RESERVOIR

Geological Horizon: Lower Grand Rapids - G.P.

Depth to Top of Formation: 375 m

Reservoir Thickness:
net: 12 m

gross: 17 m

Original Temperature: 15°C

Original Pressure: 3000 kPa

Average Horizontal Permeability: 3 Darcies

Average Porosity: 35%

Average Water Saturation S_w : 25%

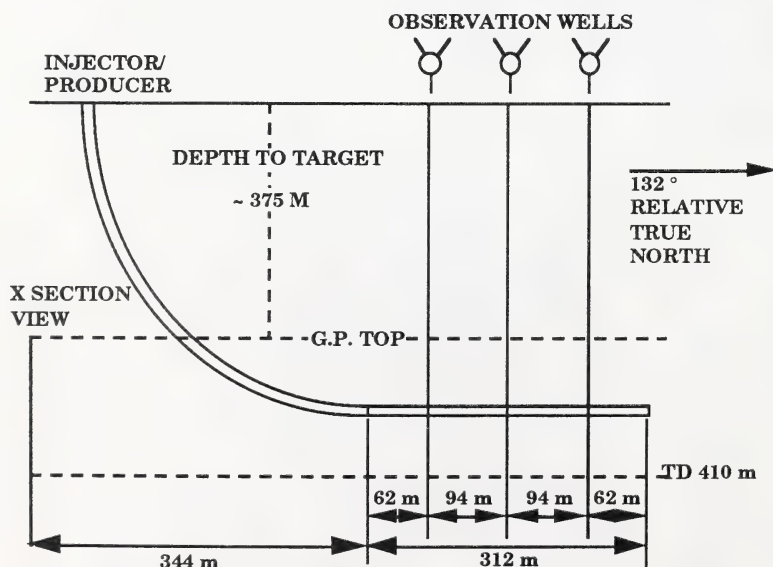
Average Oil Saturation S_o : 75% pore volume

Oil Viscosity at Res. Temp. 100,000 mPa.s

Oil Gravity at Reservoir Temp. 997 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator



Murphy Oil Company Ltd.

Lindbergh

LOCATION

LSD 6 Section: 13 Township: 58 Range: 5 W4M

PARTNERS:

Murphy Oil Company Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST:

Capital - \$7 MM

Operating - \$2.5 MM/Yr.

START-UP: 1974

TERMINATION: Partially Suspended

DESCRIPTION

PILOT AREA: 20.23 ha

WELL PATTERN: Elongated 7-Spot

WELL SPACING: 2.02 ha

NO. OF WELLS:

Injection/Production 16

Observation 0

FACILITIES

STEAM GENERATOR(S): one - 21 GJ/hr steam generator and one - 53 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Insert Pumps

TREATER TYPE: Murphy Evaporation Dehydrator

STORAGE FACILITIES: Tied into commercial expansion.

TRANSPORT: Truck

RESERVOIR

Geological Horizon: Lower Grand Rapids

Depth to Top of Formation: 510 m.KB

Reservoir Thickness:

net: 20 m

gross: 20 m

Original Temperature: 21°C

Original Pressure: 2700 kPa

Average Horizontal Permeability: 2500 md

Average Porosity: 33%

Average Water Saturation S_w 18%

Average Oil Saturation S_o 82% pore volume

Oil Viscosity at Reservoir Temp. 100,000 mPa.s

Oil Gravity at Reservoir Temp. 990 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator

Murphy Oil Company Ltd.

Morgan

LOCATION

LSD 11 Section: 2 Township: 52 Range: 4 W4M

PARTNERS:

Murphy Oil Company Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST: Operating - \$0.2 MM/Yr.

START-UP: September 1985

TERMINATION:

DESCRIPTION

PILOT AREA: 4 ha

WELL PATTERN: Single Well

WELL SPACING:

NO. OF WELLS:

Injection	1
Production	1
Observation	0

FACILITIES

STEAM GENERATOR(S): Portable Rental

ARTIFICIAL LIFT METHODS: Insert Pump

TREATER TYPE: None

STORAGE FACILITIES: 2 x 120 m³

TRANSPORT: Truck

RESERVOIR

Geological Horizon: Lloydminster A

Depth to Top of Formation: 574 m.KB

Reservoir Thickness:

net: 13 m

gross: 13 m

Original Temperature: 21°C

Original Pressure: 3450 kPa

Average Horizontal Permeability: 1800 md

Average Porosity: 33%

Average Water Saturation S_w 30%

Average Oil Saturation S_o 70% pore volume

Oil Viscosity at Reservoir Temp. 14,500 mPa.s

Oil Gravity at Reservoir Temp. 994 Kg/m³

Primary Production Rates: 1.75 m³/well/day

Source: Pilot Operator

Norcen Energy Resources Ltd.

Lindbergh I

LOCATION

LSD 3,4,6,9,16 Section: 13 Township: 55 Range: 6 W4M

LSD 16 Section: 21 Township: 55 Range: 6 W4M

LSD 10 Section: 15 Township: 55 Range: 5 W4M

LSD 06 Section: 21 Township: 55 Range: 5 W4M

LSD 10 Section: 01 Township: 55 Range: 6 W4M

LSD 10 Section: 15 Township: 56 Range: 6 W4M

LSD 14 Section: 01 Township: 56 Range: 6 W4M

LSD 7 Section: 27 Township: 55 Range: 6 W4M

LSD 2 Section: 35 Township: 55 Range: 6 W4M

PARTNERS:

Norcen Energy Resources Ltd. 100%

PROCESS: Cyclic Huff & Puff

COST: \$7,300,000

START-UP: May 1982

TERMINATION: Continuing

DESCRIPTION

PILOT AREA: 178 ha

WELL PATTERN: Single Well

WELL SPACING: 16 ha

NO. OF WELLS:

Injection/Production 13

Observation 0

FACILITIES

STEAM GENERATOR(S): two - 23.2 GJ/hr steam generators

ARTIFICIAL LIFT METHODS: Conventional Tubing Pump and Pump Jack System

TREATER TYPE: H.T.I.

STORAGE FACILITIES: 3 - 119 m³ Tanks/Well

TRANSPORT: Trucked to Westmin Cleaning Plant and shipped via Husky pipeline to Lloydminster.

RESERVOIR

Geological Horizon: Cummings

Depth to Top of Formation: 600 m.KB

Reservoir Thickness:

net: 12.6 m

gross: 15.0 m

Original Temperature: 24°C

Original Pressure: 3900 kPa

Average Horizontal Permeability: 2400 md

Average Porosity: 30%

Average Water Saturation S_w : 20%

Average Oil Saturation S_o : 80% pore volume

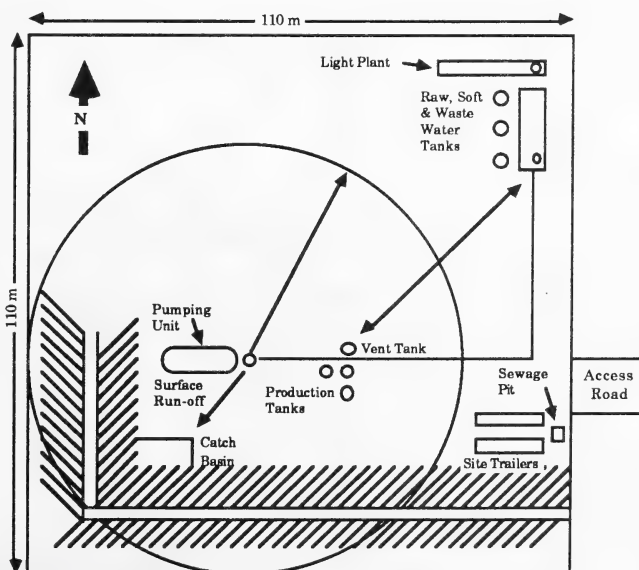
Oil Viscosity at Reservoir Temp. 9800 mPa.s

Oil Gravity at Reservoir Temp. 986 Kg/m³

Primary Production Rates: 5.0 m³/well/day

Source: Pilot Operator

COMMENTS: Experimental Operations Continuing at all locations.



Norcen Energy Resources Ltd.

Lindbergh II

LOCATION

LSD 1,2,7,8 Section: 13 Township: 55 Range: 6
W4M

PARTNERS:

Norcen Energy Resources Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST: Capital -\$7,500,000

START-UP: October 1984

TERMINATION: Continuing

DESCRIPTION

PILOT AREA: 64.6 ha

WELL PATTERN: 9-Spot

WELL SPACING: 4.05 ha

NO. OF WELLS:

Injection/Production 16

Observation 0

FACILITIES

STEAM GENERATOR(S): one - 52.75 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Conventional Tubing Pump and Pump Jack System

TREATER TYPE: H.T.I. Pump Jack System

STORAGE FACILITIES: two - 150 m³ tanks

TRANSPORT: Pipeline

RESERVOIR

Geological Horizon: Cummings

Depth to Top of Formation: 600 m.KB

Reservoir Thickness:
net: 13.12 m

gross: 15 m

Original Temperature: 24°C

Original Pressure: 3900 kPa

Average Horizontal Permeability: 2838 md

Average Porosity: 25.2%

Average Water Saturation S_w 19.9%

Average Oil Saturation S_o 80.1% pore volume

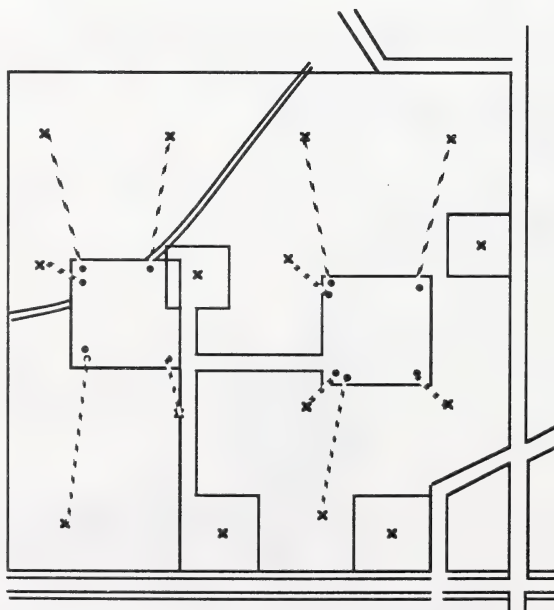
Oil Viscosity at Reservoir Temp. 9800 mPa.s

Oil Gravity at Reservoir Temp. 986 Kg/m³

Primary Production Rates: 6.0 m³/well/day
Source: Pilot Operator

COMMENTS:

Commissioning of steam generator in May, 1987 with steam injection commenced in June 1987. 13 wells steamed to date.



Norcen Energy Resources Ltd.

Lindbergh III

LOCATION

LSD 11,12,13,14 Section: 13 Township: 55 Range: 6 W4M

PARTNERS:

Norcen Energy Resources Ltd. 100%

PROCESS: Modified Steam Drive

COST: Capital -\$6,000,000

START-UP: December 1985

TERMINATION: Continuing

DESCRIPTION

PILOT AREA: 64.6 ha

WELL PATTERN: Inverted 9-Spot with Production Control Wells

WELL SPACING: 4.02 ha/well

NO. OF WELLS:

Injection	1
Production	15
Observation	2

FACILITIES

STEAM GENERATOR(S): one - 23.2 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Conventional tubing and pump and pump jack system and progressive cavity pump system.

TREATER TYPE: H.T.I.

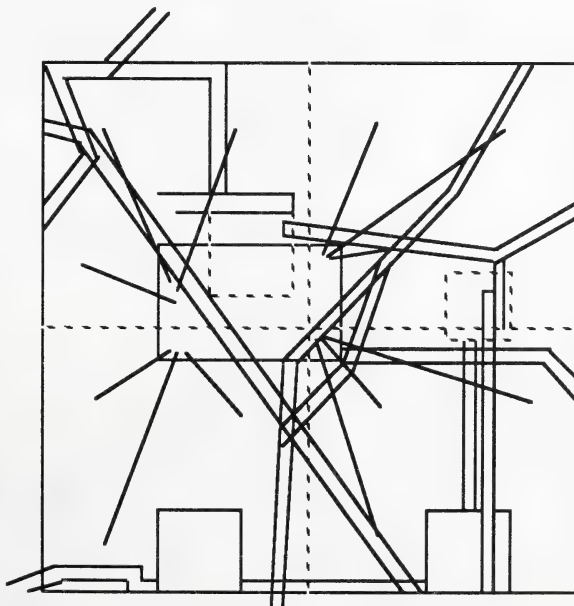
STORAGE FACILITIES: 15 - 119 m³ tanks

TRANSPORT: Trucked to Westmin cleaning plant and shipped via Husky pipeline to Lloydminster.

RESERVOIR

Geological Horizon:	Cummings
Depth to Top of Formation:	600 m.KB
Reservoir Thickness:	
net:	7.31 m
gross:	7.31 m
Original Temperature:	24°C
Original Pressure:	3200 kPa
Average Horizontal Permeability:	3230 md
Average Porosity:	24.7%
Average Water Saturation S_w	20.9%
Average Oil Saturation S_o	79.1% pore volume
Oil Viscosity at Reservoir Temp.	9750 mPa.s
Oil Gravity at Reservoir Temp.	986 Kg/m ³
Primary Production Rates:	6.0 m ³ /well/day
Source:	Pilot Operator

COMMENTS: Steam injection commenced in May, 1986 and operation continuing.



Norcen Energy Resources Ltd.

Lloydminster Horizontal Well

LOCATION

LSD 3, 4, & 5 Section: 36 Township: 50 Range: 2 W4M

PARTNERS:

Norcen Energy Resources Ltd.

PROCESS: Horizontal primary production

COST: n/a

START-UP: February 1989

TERMINATION: On-going

DESCRIPTION

Lloydminster Horizontal Well - to evaluate productivity improvements and increased recovery of a horizontal well compared to a vertical well.

PILOT AREA: 120 acres special spacing unit (see attached map)

WELL PATTERN: Single well

WELL SPACING: 40 acres

NO. OF WELLS: 1

FACILITIES

STEAM GENERATOR(S): n/a

ARTIFICIAL LIFT METHODS: Progressive cavity pump

TREATER TYPE: n/a

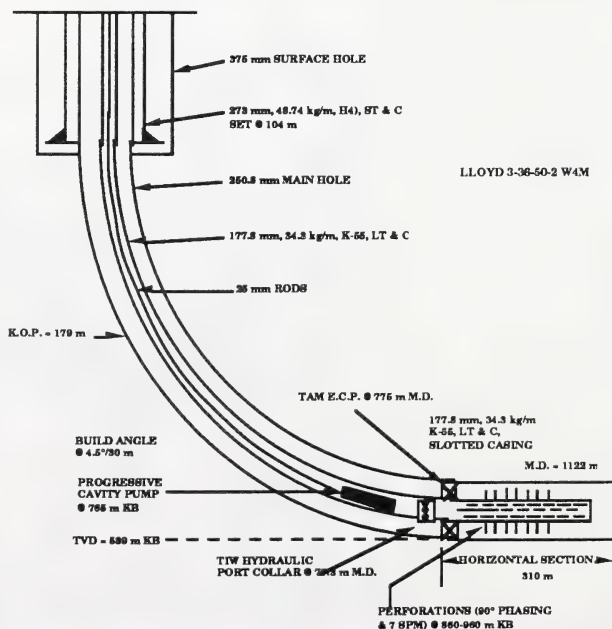
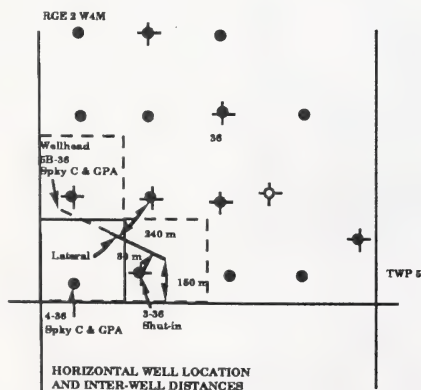
STORAGE FACILITIES: Lease tank

TRANSPORT: Trucked

RESERVOIR

Geological Formation:	Sparky "B"
Depth to Top of Formation:	585 m
Reservoir Thickness:	
net:	7.5 m
gross:	10.4 m
Original Temperature:	20°C
Original Pressure:	3718 kPa
Average Horizontal Permeability:	1-3 Darcies
Average Porosity:	29%
Average Water Saturation S_w	80%
Average Oil Saturation S_o	20%
Live Oil Viscosity at Reservoir Temp.	2270 mPa.s
Oil Gravity at Reservoir Temp.	967 Kg/m ³
Primary Vertical Production Rates:	5.0 m ³ /well/day
Source:	Pilot Operator

COMMENTS: Horizontal well was completed in the middle Sparky which has only 6.0 m net pay. Because of completion problems only 200 m out of the total horizontal section of 300 m is open to the formation.



Norcen Energy Resources Ltd.

Provost (BODO)

LOCATION

LSD 5 Section: 20 Township: 37 Range: 1 W4M

PARTNERS:

Norcen Energy Resources Ltd.
Canadian Occidental Petroleum Ltd.
Murphy Oil Company Ltd.
Texaco Canada Resources

AOSTRA

PROCESS: Cyclic Steam Stimulation followed by Steamflood.

COST:

Capital - \$14 MM
Operating - \$2.5 MM/Yr.
START-UP: February 1985
TERMINATION: 1992

DESCRIPTION

PILOT AREA: 8 ha

WELL PATTERN: Single Inverted Nine-Spot Pattern.

NO. OF WELLS:

Injection	1
Production	8
Observation	3

FACILITIES

STEAM GENERATOR(S): one - 26 GJ/hr steam generator

ARTIFICIAL LIFT METHODS: Five HEP Pumping Units and three Le Grand 456 Conventional Pumping Unit.

TREATER TYPE: Complete tank farm and battery with distillation/evaporation type treater.

TRANSPORT: Pipeline to Sales

RESERVOIR

Geological Formation: McLaren Sand of the Upper Mannville Group

Depth to Top of Formation: 720 m.KB

Reservoir Thickness:

net: 15 m

gross: up to 24 m

Original Temperature: 27°C

Original Pressure: 5450 kPa

Average Horizontal Permeability: 1000-5000 md

Average Porosity: 30%

Average Water Saturation S_w : 20%

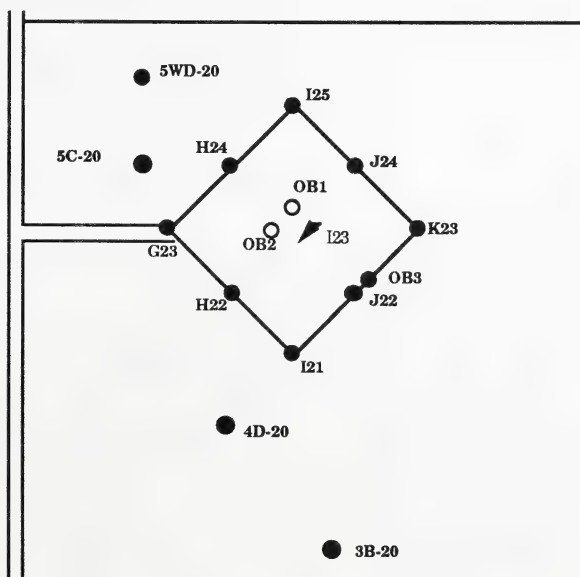
Average Oil Saturation S_o : 80%

Oil Viscosity at Reservoir Temp. 2300 mPa.s

Oil Gravity at Reservoir Temp. 979 Kg/m³

Primary Production Rates: 4-5 m³/well/day

Source: Pilot Operator



PanCanadian Petroleum Ltd.

Countess B

LOCATION

LSD ____ Section: 16 Township: 29 Range: 16
W4M

PARTNERS:

PanCanadian Petroleum Ltd.	50%
LL&E	50%
Relative to Licensing Revenue:	
PanCanadian Petroleum Ltd.	45%
LL&E	45%
AOSTRA	10%

PROCESS: Combination Thermal Drive

COST:

Capital - \$3,900,000 to September 30, 1989
Operating - \$4,888,000 to September 30, 1989

START-UP: December 1982

TERMINATION: 1990 (air injection only)

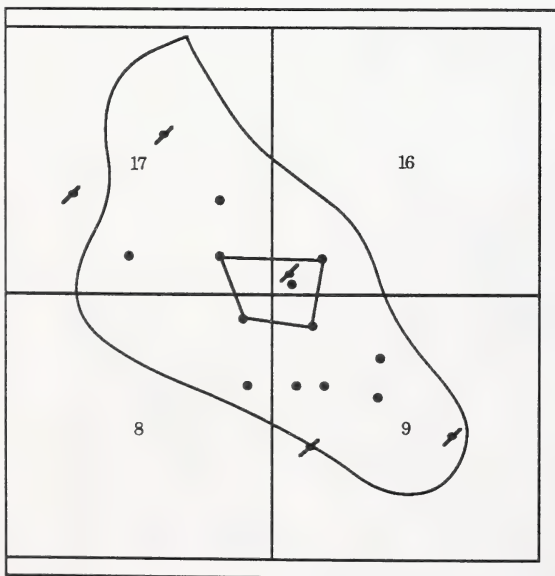
DESCRIPTION

PILOT AREA: 16.3 ha

WELL PATTERN: Inverted 5-Spot

NO. OF WELLS:

Injection	1
Production	4
Observation/Sampling Well	1
Post Combustion Core Well	1



FACILITIES

COMPRESSOR(S): No. - 2 boosters and one main
air compressor - Capacity 56,600 m³/d @ 24.1 MPa

ARTIFICIAL LIFT METHODS: Sucker Rod Pumps

TREATER TYPE: Horizontal Murdoch HOWG

STORAGE FACILITIES: Oil Production and
Shipping Tanks.

TRANSPORT: LACT, BRPL

RESERVOIR

Geological Horizon: Countess Upper Mannville B

Depth to Top of Formation: 1083 m.KB

Reservoir Thickness:
net: 5.8-10.4 m
gross: m

Original Temperature: 37°C

Original Pressure: 10,000 kPa

Average Horizontal Permeability: 800 md

Average Porosity: 25%

Average Water Saturation S_w 50%

Average Oil Saturation S_o 50% pore volume

Oil Viscosity at Reservoir Temp. 6 mPa.s

Oil Gravity at Reservoir Temp. 887 Kg/m³

Primary Production Rates: 12 m³/well/day
Source: Pilot Operator

COMMENTS: Air injection continues, but nearing
point of conversion to water injection for heat
scavenging.

Planning additional 2 patterns and 3 air injectors to
south.

Cumulative combustion gas composition to the end
of 1989 follows:

Nitrogen	=	73.00%
Carbon Dioxide	=	10.00%
Carbon Monoxide	=	0.24%
Oxygen	=	0.67%

Technically successful.

PanCanadian Petroleum Ltd.

Lindbergh

LOCATION

LSD ____ Section: 07 Township: 55 Range: 5 W4M

LSD ____ Section: 03 Township: 56 Range: 6 W4M

PARTNERS:

PanCanadian Petroleum Ltd. 100%

PROCESS: Cyclic Steam Stimulation

COST:

Capital - \$60,000/well (est.)

Operating - \$150,000/well/yr.

START-UP: September 1983 (as per Approval No. 3886)

TERMINATION: 1989

DESCRIPTION

PILOT AREA: N/A

WELL PATTERN: N/A

WELL SPACING: 4 ha - 16 ha

NO. OF WELLS:

Injection/Production 18

FACILITIES

STEAM GENERATOR(S): one - 25 MMBtu

ARTIFICIAL LIFT METHODS: Standard steam and heavy oil sucker rod pump.

TREATER TYPE:

STORAGE FACILITIES: Standard stock tanks

TRANSPORT: Truck, LACT Unit

RESERVOIR

Geological Horizon: Cummings B & C

Depth to Top of Formation: 580 m.KB

Reservoir Thickness:

net: 9 (Sec. 7) 12 (Sec. 3) m

gross: 12 (Sec. 7) 18 (Sec. 3) m

Original Temperature: 24°C

Original Pressure: 4400 kPa

Average Horizontal Permeability: 1000 md

Average Porosity: 30%

Average Water Saturation S_w 20%

Average Oil Saturation S_o 80% pore volume

Oil Viscosity at Reservoir Temp. 3000 mPa.s

Oil Gravity at Reservoir Temp. 986 Kg/m³

Primary Prod. Rates: 2 (Sec. 7) m³/well/day

6 (Sec. 3) m³/well/day

Source: Pilot Operator

PanCanadian Petroleum Ltd.

Lindbergh - Elk Point

LOCATION

LSD 11 Section: 03 Township: 56 Range: 6 W4M
Lindbergh

PARTNERS:

PanCanadian Petroleum Ltd. 100%

PROCESS: Steamflood Pilot

COST:

Capital - \$520 M

Operating - \$1600/day

START-UP: By May 1990 (as per Approval #6099)

TERMINATION: 1991

DESCRIPTION

Steamflood Pilot Project application was made to the ERCB in January 1990. Pilot steamflood will be conducted in section 3-56-6W4M

PILOT AREA: 4 ha

WELL PATTERN: inverted 5-spot

WELL SPACING: 4 ha

NO. OF WELLS: 1 injection/4 production

FACILITIES

STEAM GENERATOR(S): one - 25 MMBtu

ARTIFICIAL LIFT METHODS: Screw pump/standard steam and heavy oil sucker rod.

TREATER TYPE:

STORAGE FACILITIES: Standard stock tanks

TRANSPORT: Truck, LACT

RESERVOIR

Geological Horizon: Cummings B & C

Depth to Top of Formation: 603 m.KB

Reservoir Thickness:

net: 13 m

gross: 18 m

Original Temperature: 24°C

Original Pressure: 4400 kPa

Average Horizontal Permeability: 1000 md

Average Porosity: 30%

Average Water Saturation S_w 22%

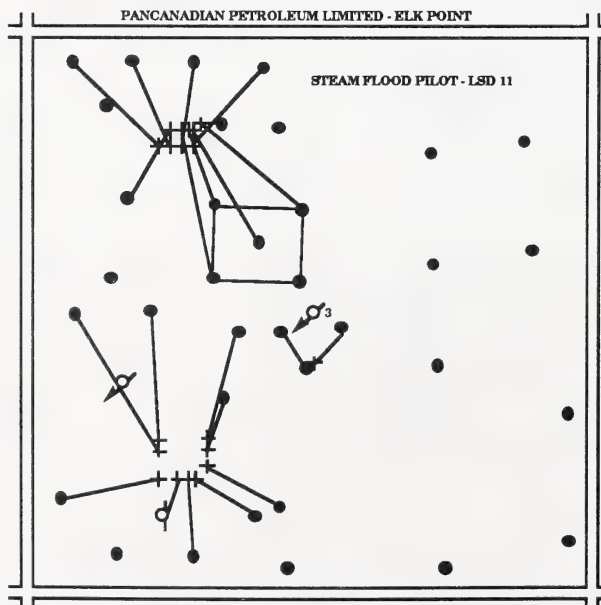
Average Oil Saturation S_o 78% pore volume

Oil Viscosity at Reservoir Temp. 3000 mPa.s

Oil Gravity at Reservoir Temp. 985 Kg/m³

Primary Prod. Rates: 6 m³/well/day

Source: Pilot Operator



Petro-Canada Resources

Hangingsstone I

LOCATION

LSD 13 Section: 27 Township: 84 Range: 11 W4M

PARTNERS:

Petro-Canada Resources	25%
Canadian Occidental Petroleum Ltd.	25%
Esso Resources Canada Ltd.	25%
Japan Canada Oil Sands	25%

PROCESS: Cyclic Steam Stimulation

COST: N/A

START-UP: February 1, 1985

TERMINATION: January, 1988

DESCRIPTION

PILOT AREA: Single Well Test

FACILITIES

STEAM GENERATOR(S): one - 26 GJ/hr portable steam generator

ARTIFICIAL LIFT METHODS: Standard Pump Jack

TREATER TYPE: Atmospheric Treating Tank

STORAGE FACILITIES: Tank Farm on Site

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	McMurray
Depth to Top of Formation:	261 m.KB
Reservoir Thickness:	
net:	43 m
gross:	51 m
Original Temperature:	15°C
Original Pressure:	2200 kPa
Average Horizontal Permeability:	1350 md
Average Porosity:	32%
Average Water Saturation - S_w	17%
Average Oil Saturation S_o	83% pore volume
Oil Viscosity at Reservoir Temp.	800,000 mPa.s
Oil Gravity at Reservoir Temp.	1008 Kg/m ³
Primary Production Rates:	0 m ³ /well/day
Source:	Pilot Operator

Petro-Canada Resources

Hangingsstone II

LOCATION

LSD 16 Section: 27 Township: 84 Range: 11 W4M

PARTNERS:

Petro-Canada Resources	25%
Canadian Occidental Petroleum Ltd.	25%
Esso Resources Canada Ltd.	25%
JACOS	25%

PROCESS: Cyclic Steam Stimulation

COST: N/A

START-UP: April 1986

TERMINATION: -

DESCRIPTION

PILOT AREA: Single Well Test

FACILITIES

STEAM GENERATOR(S): one - 26 GJ/hr portable steam generator

ARTIFICIAL LIFT METHODS: Standard Pump Jack

TREATER TYPE: Atmospheric Treating Tank

STORAGE FACILITIES: Tank Farm on Site

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	McMurray
Depth to Top of Formation:	261 m.KB
Reservoir Thickness:	
net:	26 m
gross:	51 m
Original Temperature:	15°C
Original Pressure:	2200 kPa
Average Horizontal Permeability:	1350 md
Average Porosity:	32%
Average Water Saturation S_w	17%
Average Oil Saturation S_o	83% pore volume
Oil Viscosity at Reservoir Temp.	800,000 mPa.s
Oil Gravity at Reservoir Temp.	1008 Kg/m ³
Primary Production Rates:	0 m ³ /well/day
Source:	Pilot Operator

Petro-Canada Resources

Hangingsstone III

LOCATION

LSD 4 Section: 35 Township: 84 Range: 11 W4M

PARTNERS:

Petro-Canada Resources	25%
Canadian Occidental Petroleum Ltd.	25%
Esso Resources Canada Ltd.	25%
Japan Canada Oil Sands	25%

PROCESS: Cyclic Steam Stimulation

COST: N/A

START-UP: February 1, 1985

TERMINATION: -

DESCRIPTION

PILOT AREA: Single Well Test

FACILITIES

STEAM GENERATOR(S): one - 26 GJ/hr portable steam generator

ARTIFICIAL LIFT METHODS: Standard Pump Jack

TREATER TYPE: Atmospheric Treating Tank

STORAGE FACILITIES: Tank Farm on Site

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	McMurray
Depth to Top of Formation:	263 m.KB
Reservoir Thickness:	
net:	17 m
gross:	35 m
Original Temperature:	15°C
Original Pressure:	2200 kPa
Average Horizontal Permeability:	1350 md
Average Porosity:	32%
Average Water Saturation S_w	15%
Average Oil Saturation S_o	85% pore volume
Oil Viscosity at Reservoir Temp.	800,000 mPa.s
Oil Gravity at Reservoir Temp.	1008 Kg/m ³
Primary Production Rates:	0 m ³ /well/day
Source:	Pilot Operator

Petro-Canada Resources

PCEJ

LOCATION

LSD 1 Section: 34 Township: 84 Range: 11 W4M

PARTNERS:

Petro-Canada Resources	25%
Canadian Occidental Petroleum Ltd.	25%
Esso Resources Canada Ltd.	25%
Japan Canada Oil Sands	25%

PROCESS: Steam Stimulation

COST: N/A

START-UP: 1990

TERMINATION:

DESCRIPTION

13 well pilot

PILOT AREA:

WELL PATTERN: Inverted 5-Spots

WELL SPACING: 1.6 ha/well

NO. OF WELLS: 13

FACILITIES

ARTIFICIAL LIFT METHODS: Standard Pump Jack

TREATMENT TYPE:

STORAGE FACILITIES: Tank farm on site

TRANSPORT: Truck

RESERVOIR

Geological Horizon:	McMurray
Depth to Top of Formation:	285 m
Reservoir Thickness:	
net:	27 m
gross:	30 m
Original Temperature:	15°C
Original Pressure:	2200 kPa
Average Horizontal Permeability:	1350 md
Average Porosity:	32%
Average Water Saturation S_w	10%
Average Oil Saturation S_o	90% pore volume
Oil Viscosity at Reservoir Temp.	800,000 mPa.s
Oil Gravity at Reservoir Temp.	1008 Kg/m ³
Primary Production Rates:	nil m ³ /well/day
Source:	Pilot Operator

COMMENTS: Pilot design not completely finalized at this time.

Petro-Canada Resources

Viking-Kinsella B

LOCATION

LSD 2 Section: 24 Township: 48 Range: 9 W4M

PARTNERS:

Petro-Canada Resources
81.125%
PanCanadian Petroleum Ltd.
16.538%
Dome Petroleum Ltd.
2.337%

PROCESS: Oxygen In Situ Combustion

COST: N/A

START-UP: January 1984

TERMINATION: December 1987

DESCRIPTION

PILOT AREA: 8 ha

WELL PATTERN: Inverted 5-Spot

WELL SPACING: 4 ha

NO. OF WELLS:

Injection	1
Production	4
Observation	2

FACILITIES

ARTIFICIAL LIFT METHODS: Insert Pumps

TREATER TYPE: Production to existing Kinsella B Battery

STORAGE FACILITIES: Production to existing Kinsella B Battery

TRANSPORT: Battery production shipped via pipeline.

RESERVOIR

Geological Horizon: Sparky

Depth to Top of Formation: 652 m.KB

Reservoir Thickness:

net: 4.0 m

gross: 5.0 m

Original Temperature: 28°C

Original Pressure: 5030 kPa

Average Horizontal Permeability: 200 md

Average Porosity: 30%

Average Water Saturation S_w 33%

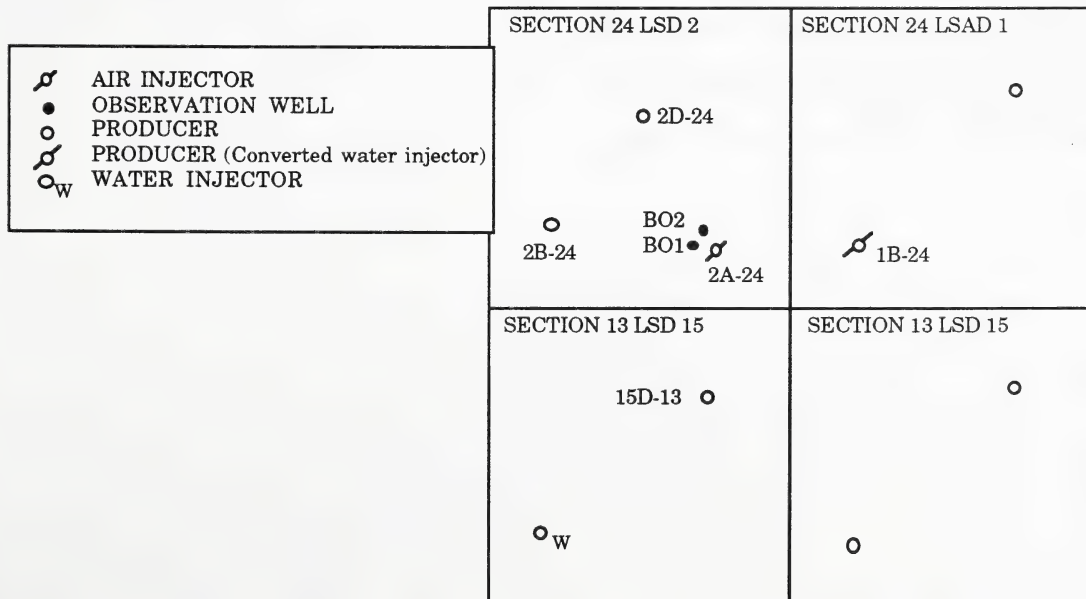
Average Oil Saturation S_o 67% pore volume

Oil Viscosity at Reservoir Temp. 100 mPa.s

Oil Gravity at Reservoir Temp. 934 Kg/m³

Primary Production Rates: nil m³/well/day

Source: Pilot Operator



Renaissance Energy Ltd.

Horizontal Well

LOCATION

LSD 11B Section: 21 Township: 20 Range: 8 W4M

PARTNERS:

Renaissance

100%

PROCESS: Horizontal Well

COST: Approximately \$500,000

START-UP: June 1989

TERMINATION: January 31, 1994

DESCRIPTION

300 m long horizontal well drilled within 4 m of the top of the Glauco sand, and approximately 12 m above oil/water contact

PILOT AREA:

WELL PATTERN: Standard 10 acre spacing

WELL SPACING: 10 acres

NO. OF WELLS: Two horizontal wells both approximately 300 m long one 10 acre producer in 11B-21

FACILITIES

STEAM GENERATOR(S): n/a

ARTIFICIAL LIFT METHODS: High volume rotary pumps

TREATER TYPE: Well is tied into Renaissance Battery at 6-21-20-8 W4M

STORAGE FACILITIES: Standard conventional oil storage and treating facilities

TRANSPORT: Tied into Bow Island Pipeline system

RESERVOIR

Geological Horizon: Upper Mannville

Depth to Top of Formation: 918.6 m.KB

Reservoir Thickness:

net: 16.0 m

gross: 35.0 m

Original Temperature: 28°C

Original Pressure: 10410 kPa

Average Horizontal Permeability: 4.0D

Average Porosity: 25%

Average Water Saturation S_w 25%

Average Oil Saturation S_o 75% pore volume

Oil Viscosity at Reservoir Temp. 1100 mPa.s

Oil Gravity at Reservoir Temp. 979 Kg/m³

Primary Production Rates: 50.0 m³/well/day

Source: Daily Production Reports

Signalta Resources Limited

Pembina - Lobstick

LOCATION

LSD 16 Section: 1 Township: 51 Range: 7 W5M

PARTNERS:

Signalta Resources Limited

PROCESS: Foam-forming surfactant with lean gas injection.

COST: N/A

START-UP: October 1986

TERMINATION: Ongoing

DESCRIPTION

PILOT AREA: 896 ha

WELL PATTERN: 64 ha

WELL SPACING: 64 ha

NO. OF WELLS:

Injection	1
Production	13
Observation	0

FACILITIES

ARTIFICIAL LIFT METHODS: Standard beam pumping unit. Two wells naturally flowing.

TREATER TYPE: Vertical (Installed 1989)

STORAGE FACILITIES: Tankage

TRANSPORT: Trucked to sales.

RESERVOIR

Geological Horizon:	Ostracod
Depth to Top of Formation:	1725 m.KB
Reservoir Thickness:	
net:	1.0 m
gross:	1.0 m
Original Temperature:	57°C
Original Pressure:	15,410 (abs) kPa
Average Horizontal Permeability:	70 md
Average Porosity:	12%
Average Water Saturation S_w	22%
Average Oil Saturation S_o	78% pore volume
Oil Viscosity at Reservoir Temp.	0.35 mPa.s
Oil Gravity at Reservoir Temp.	797 Kg/m ³
Primary Production Rates:	25 m ³ /well/day
Source:	Pilot Operator

COMMENTS: Initial reservoir conditions.

Vikor Resources Ltd.

Joffre EOR Pilot - Phase I

LOCATION

LSD ____ Section: 15, 17, 20 & 22 Township: 38

Range: 25 W4M

PARTNERS:

AOSTRA	75%
Vikor Resources Ltd.	14%
Unit Partners	11%

PROCESS: CO₂ Miscible Flood (WAG) and Mobility

Control Testing

COST: Capital - \$7,500,000

START-UP: December 1982 - First CO₂ Injection

January 1984

TERMINATION: 1990

DESCRIPTION

PILOT AREA: 129.5 ha (2 patterns)

WELL PATTERN: Two inverted 5-Spots plus two offsetting water injection wells.

NO. OF WELLS:

Injection	(water) 2
	(CO ₂ + water) 2
Production	4
Observation	0

FACILITIES

CO₂ Injection: common with Phase II

ARTIFICIAL LIFT METHODS: Conventional; subsurface pumps.

TREATER TYPE: 3-phase test and group separator and 3 phase treater.

STORAGE FACILITIES:

TRANSPORT: Crude sales through (LACT) to Gulf's Pipeline

RESERVOIR

Geological Formation: Joffre Viking A Sand

Depth to Top of Formation: 1475 m.KB

Reservoir Thickness:

net: 3 m

gross: 4.5 m

Original Temperature: 56°C

Original Pressure: 7760 kPa

Average Horizontal Permeability: 500 md

Average Porosity: 13%

Initial Water Saturation: 30%

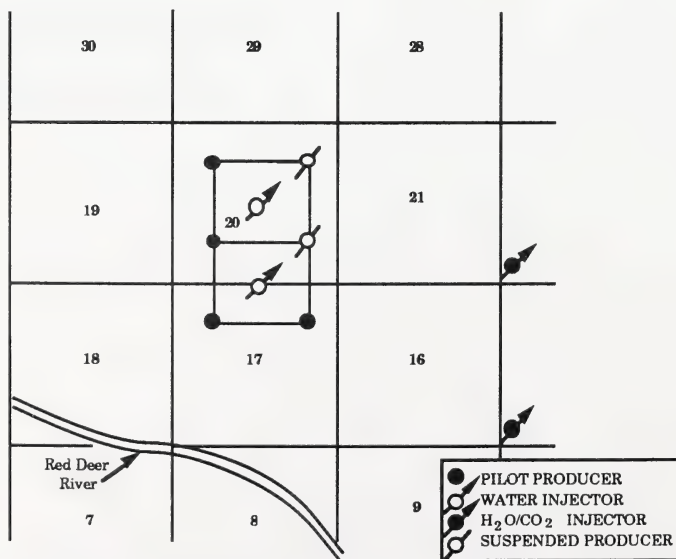
Oil Saturation After Waterflood: Appx. 40%

Oil Viscosity at Reservoir Temp. 1-2 mPa.s

Oil Gravity at Reservoir Temp. 813 kg/m³

Primary Production Rates: 7 m³/well/day

Source: AOSTRA



Vikor Resources Ltd.

Joffre EOR Pilot - Phase II

LOCATION

LSD ____ Section: 24,25,26,34 & 35 Township: 38
Range: 26 W4M

LSD ____ Section: 19 & 30 Township: 38 Range: 25
W4M

PARTNERS:

Vikor Resources Ltd.	45%
Unit Partners	35%
AOSTRA	20%

PROCESS: CO₂ Miscible Flood

COST: Capital - \$6,500,000

START-UP: July 1985 - First CO₂ Injection July 1985. Expanded in 1988.

TERMINATION: 1995

DESCRIPTION

PILOT AREA: About 450 ha

WELL PATTERN: Two Truncated Inverted 9-Spots

NO. OF WELLS:

Injection	(water) 1
	(CO ₂ + water) 2
Production	11
Observation	0

FACILITIES

Two CO₂ booster compressors - 75,000 m³/d atmos

to 1.0 MPa and injection - 115,000 m³/d 1.0 to 11 MPa

ARTIFICIAL LIFT METHODS: Conventional subsurface pumps and submersible centrifugal pumps.

TREATER TYPE: 3-phase test and group separators.

STORAGE FACILITIES:

TRANSPORT: Crude sales through (LACT) to Gulf's Pipeline

RESERVOIR

Geological Horizon: Joffre Viking A Sand

Depth to Top of Formation: 1475 m.KB

Reservoir Thickness:

net: 3 m

gross: 4.5 m

Original Temperature: 56°C

Original Pressure: 7760 kPa

Average Horizontal Permeability: 500 md

Average Porosity: 13%

Initial Water Saturation 30%

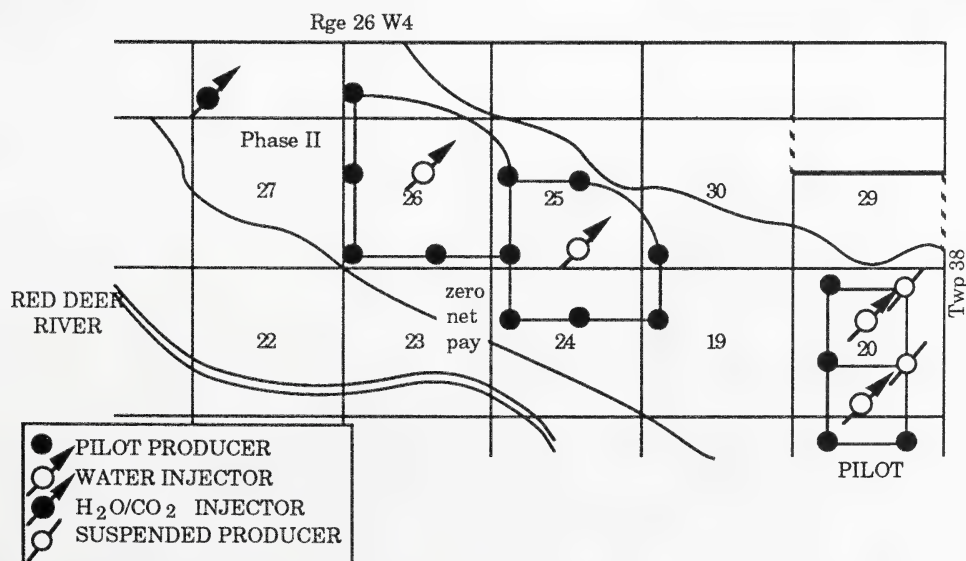
Oil Saturation After Waterflood Approx. 40%

Oil Viscosity at Reservoir Temp. 1-2 mPa.s

Oil Gravity at Reservoir Temp. 813 Kg/m³

Primary Production Rates: 7 m³/well/day

Source: AOSTRA



Ulster Petroleums Ltd.

Retlaw

LOCATION

LSD ____ Section: 4, 9, 10, 15, 16, 21, 22, 27, 28
Township: 12 Range:18 W4M

PARTNERS:

Ulster Petroleums Ltd.	39.555738%
Atcor Resources Limited	16.356042%
Canada North West Energy	14.636474%
Acanthus Resources Ltd.	1.528604%
Bobby Burns Petroleum (1977) Ltd.	12.175636%
Scurry Rainbow Oil Limited	3.106713%
PanCanadian Petroleum Limited	6.452127%
Oakwood Petroleum Ltd.	1.537419%
Bow Valley Industries Ltd.	1.537419%
Triology Resource Corporation	3.074840%
Plaza Oil & Gas Ltd.	0.038988%

N.B. AOSTRA is a consultive participant in this project.

PROCESS: CO₂ Immiscible Flood and Water Flood

Note: All CO₂ injection wells converted to water injectors. Re-injection of produced solution gas scheduled for Q2 of 1990

COST: N/A

START-UP: 1983

TERMINATION: 1989

DESCRIPTION

PILOT AREA: 1133 ha

WELL PATTERN: Seven irregular patterns.

NO. OF WELLS:

Injection	7
Production	25
Observation	0

FACILITIES

CO₂ compressed and pipeline from external sources.

ARTIFICIAL LIFT METHODS: Standard Pump Jacks

STORAGE FACILITIES: Standard oil battery facility.

RESERVOIR

Geological Horizon: Retlaw Mannville 'V' Pool
(Glaucinite Sandstone)

Mannville with hydrophilic clays) 'V' Pool

Depth to Top of Formation: 1070 m.KB

Reservoir Thickness:

net:	2 - 2.5 m
gross:	m

Original Temperature: 35°C

Original Pressure: 11,376 kPa

Average Horizontal Permeability: 50 md

Average Porosity: 18%

Average Water Saturation - S_w: 25%

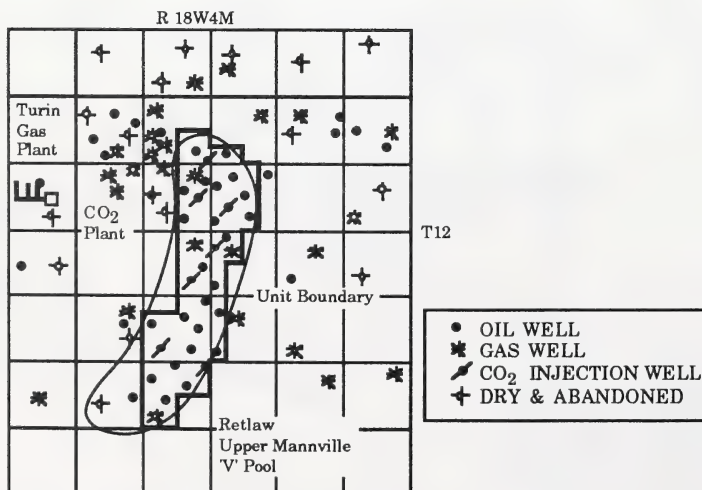
Average Oil Saturation S_o: 75% pore volume

Oil Viscosity at Reservoir Temp. 11 mPa.s

Oil Gravity at Reservoir Temp. 916 Kg/m³

Primary Production Rates: 3-40 m³/well/day

Source: Pilot Operator



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AOSTRA Advanced Oil Recovery Technologies

Leading the Way in Advanced Oil Recovery Technologies

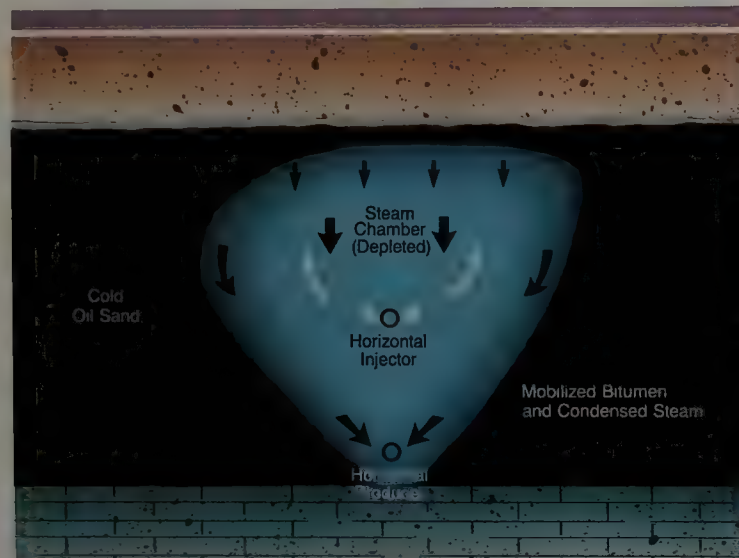
The Alberta Oil Sands Technology and Research Authority (AOSTRA), a provincial crown corporation established in 1974, has helped to make Alberta a world leader in oil recovery technologies.

AOSTRA participates directly with members of the oil industry in a variety of experimental pilot projects, and operates the multiuser Underground Test Facility (UTF). AOSTRA also sponsors and acts as a catalyst for research by universities and other research institutions.

As a result of the investment by AOSTRA and its industry partners in the research and development of Alberta's hydrocarbon resources, a \$1-billion pool of technology is available for license from AOSTRA. AOSTRA has signed technology transfer agreements with government organizations in many nations plus numerous technology licensing agreements with industry.

Resources With a Future

There are about 1.7 trillion barrels of bitumen in the oil sands and carbonate formations of Alberta plus about 8 billion barrels of heavy oil. Alberta has more than 40 percent of the



Steam-Assisted Gravity Drainage (SAGD)

Parallel horizontal wells are placed low in the reservoir. Steam is injected at the upper well, creating a steam chamber which grows as the steam condenses on the chamber walls and ceiling and releases heat. Heated bitumen and condensate drain by gravity into the lower production well.



Underground Test Facility (UTF)

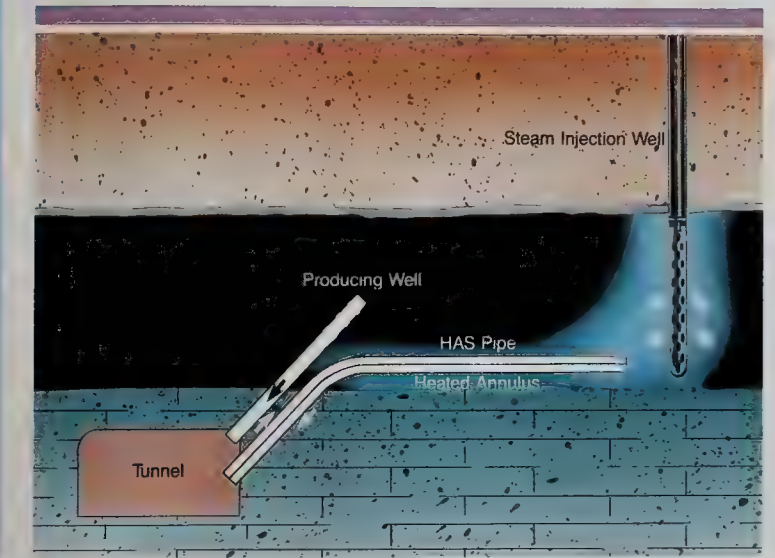
Underground access technology reduces the cost of placing horizontal wells in reservoirs and causes less environmental impact than surface in situ projects. AOSTRA'S UTF provides a facility for testing access technologies and a means of evaluating a variety of horizontal well recovery processes at a very low cost per well.

bitumen in the world. Although supplies of low-cost light oil appear to be abundant and currently satisfy more than 90 percent of world demand for petroleum, they account for less than 25 percent of the remaining world petroleum reserves. As reserves of light oil are depleted and oil prices rise, the production of oils from the oil sands and heavy oil, and through enhanced oil recovery (EOR) from conventional sources, will assume increasing importance.

Technology Benefits

AOSTRA's billion-dollar pool of technology in the Alberta oil sands, heavy oil, and conventional oil resources means outstanding benefits for Alberta:

- Innovative oil recovery technology
- Research, development, and commercialization of in situ processes, heavy-oil upgrading, and bitumen extraction
- Assured hydrocarbon supply for Canada's domestic and export requirements
- Environmentally sound technology.



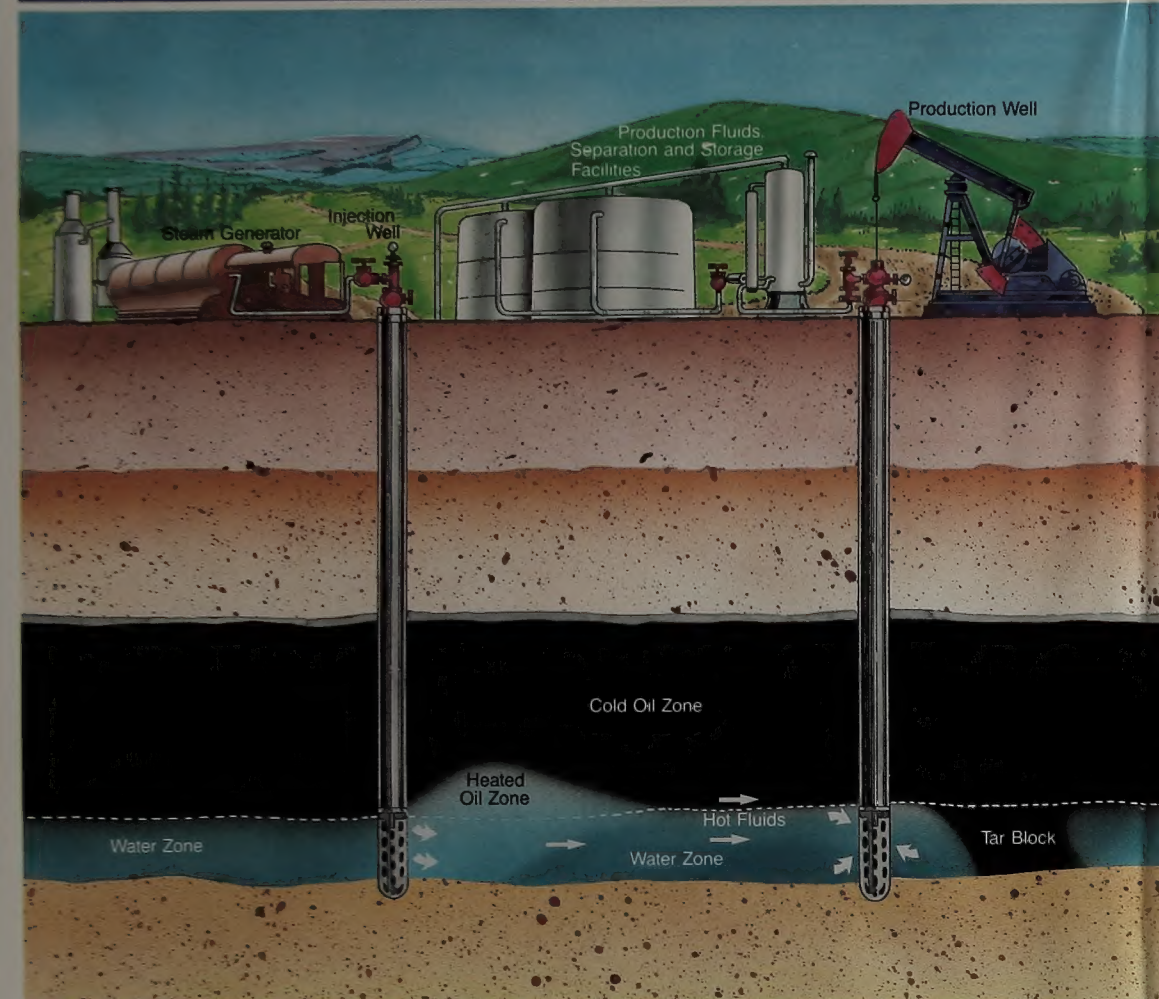
Heated Annulus Steam Drive (HASDrive)

Steam is circulated in a closed horizontal pipe placed in the pay zone. This heats a zone around the pipe, mobilizing bitumen and thus providing a path for steam flooding.

Alberta, Canada

drain by gravity into the lower production well.

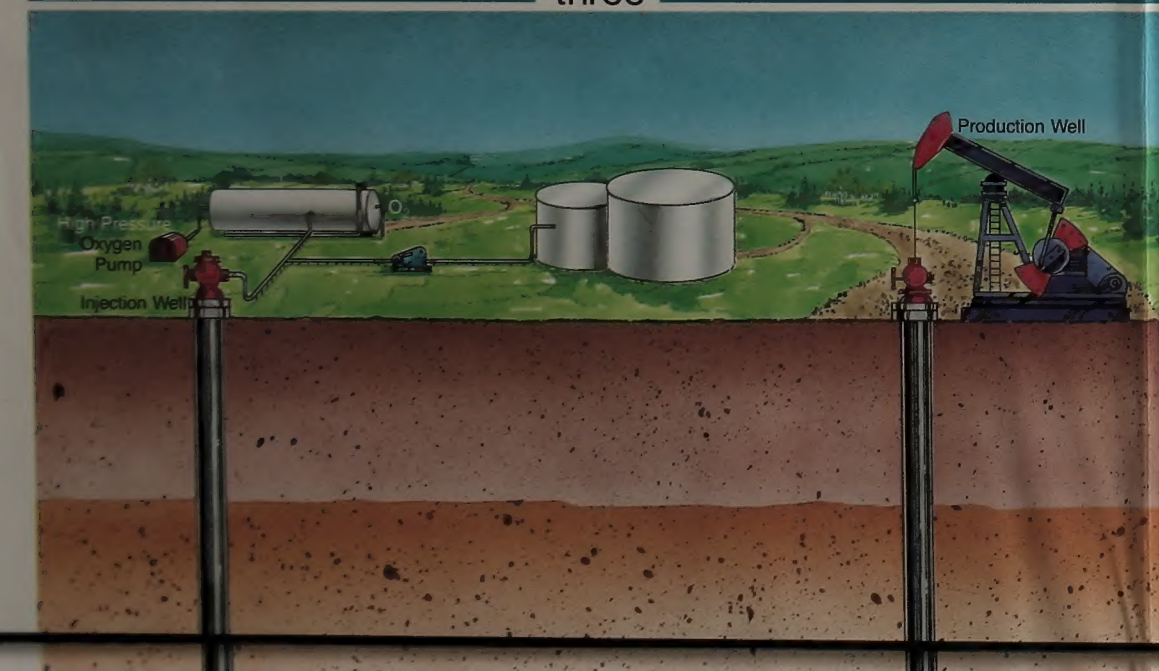
two



Pressure Cycle Steam Drive

A steam drive process with pressure cycles. Steam is injected into the reservoir without fracturing via underlying water sand which is permeable to the steam. This results in a radial heated zone at the base of the reservoir and mobilizes the overlying bitumen.

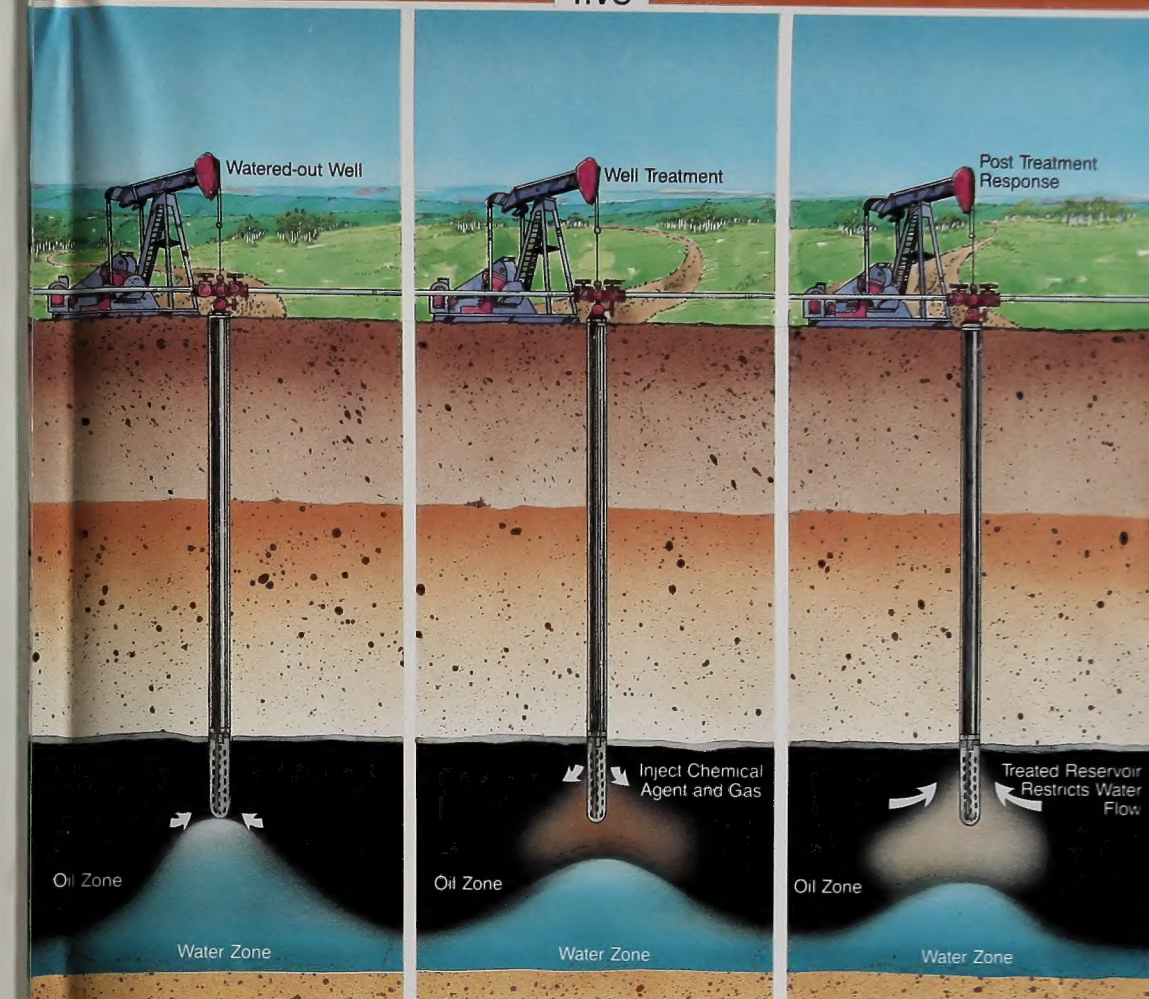
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Alberta, Canada



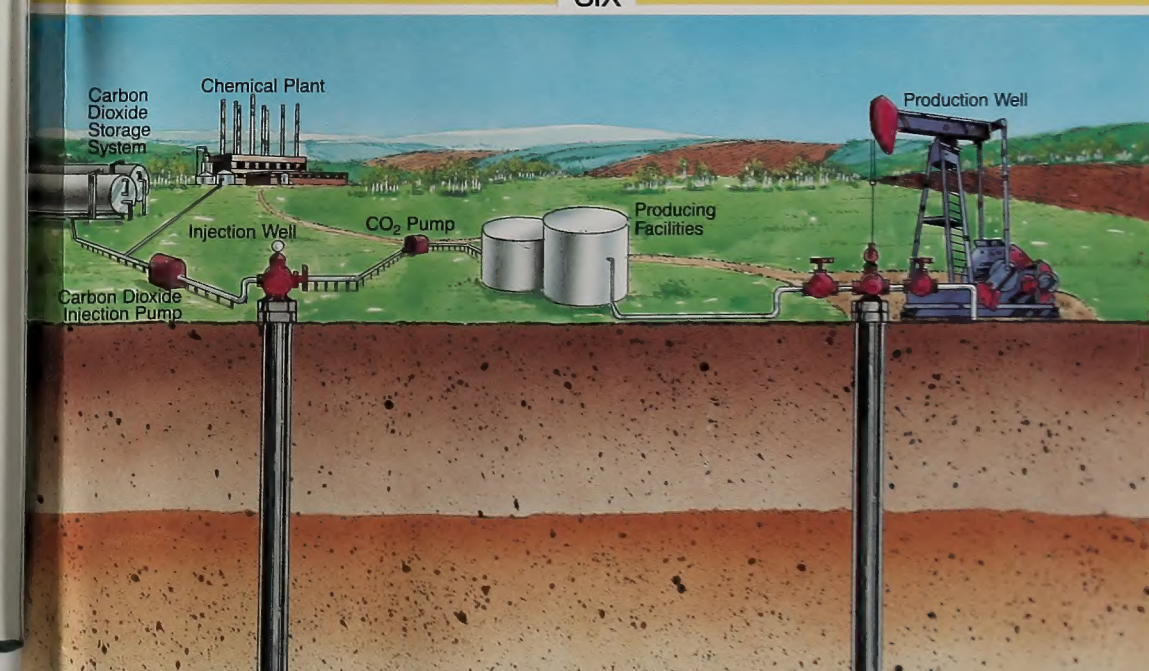
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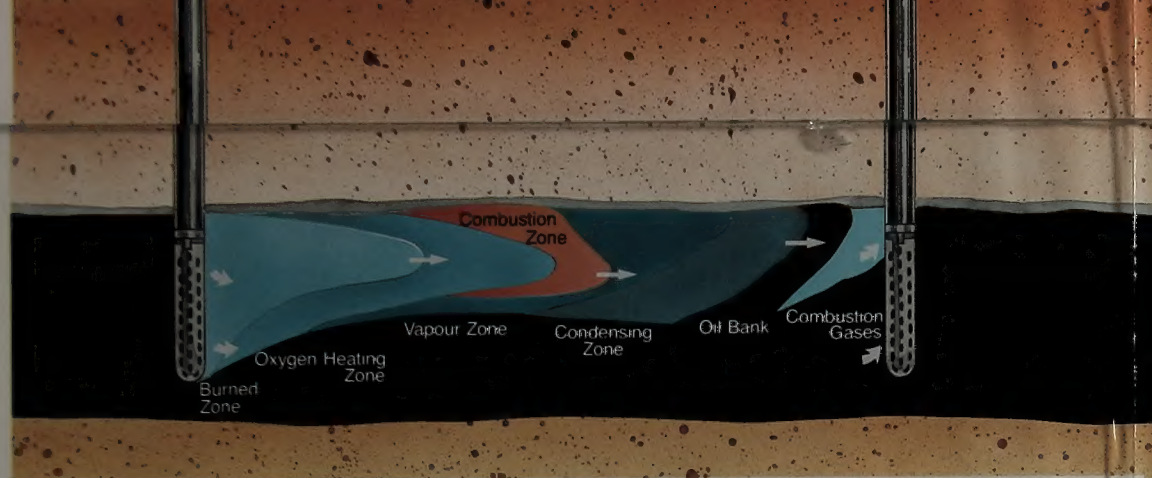


Anti-Water Coning Process

Water coning into production wells is suppressed by periodic stimulation with injections of a non-condensable gas plus a chemical agent, introduced directly or via a central injector. The technique increases oil recovery and reduces the proportion of water produced.

six

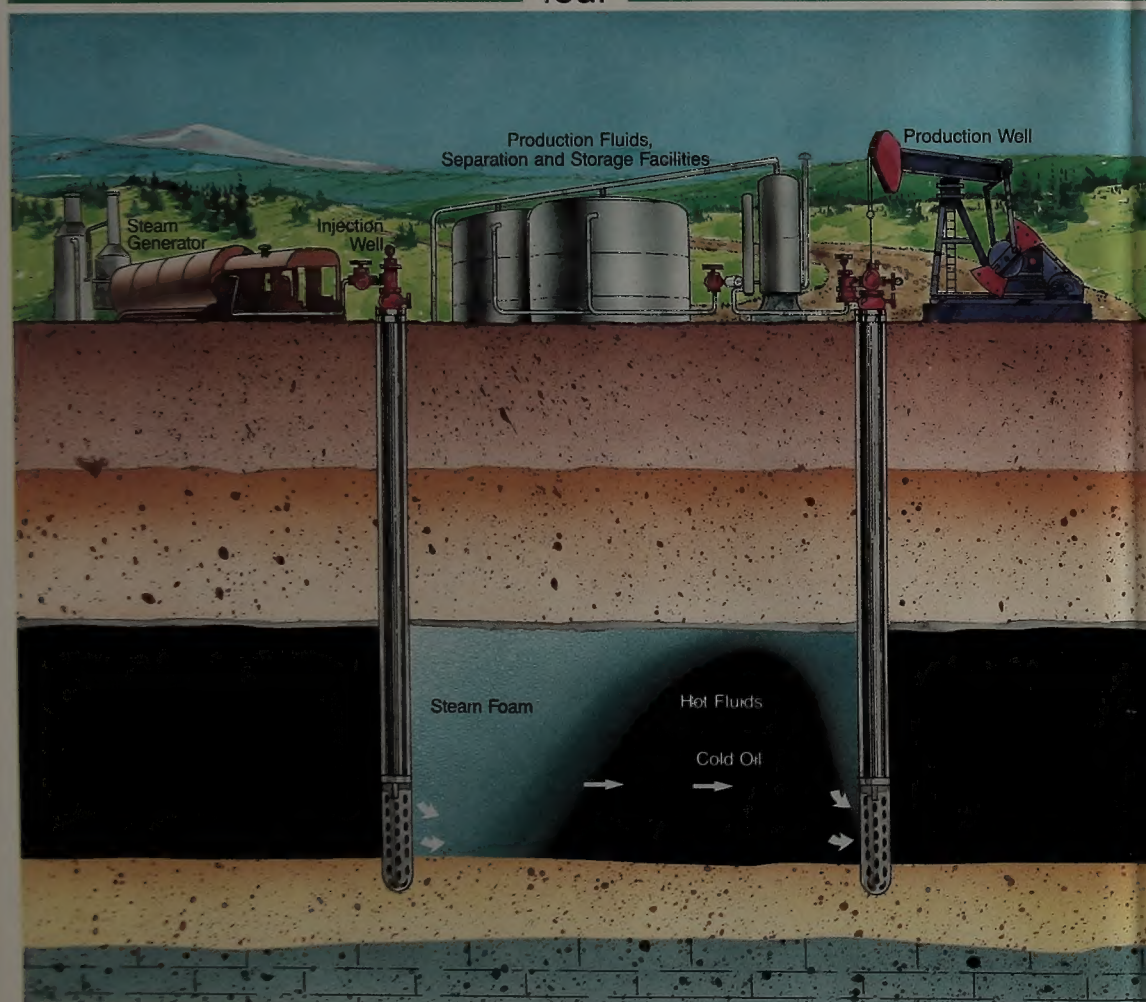




Pressure Cycle Oxygen Fire Flooding

This pressure-up/blow-down oxygen combustion process is a follow-up to cyclic steam stimulation. During the pressure-up phase, oxygen and water are injected into the reservoir where combustion heats previously unrecovered areas. Oxygen injection is then terminated and mobilized bitumen is produced in the blow-down phase. This sequence is repeated a number of times.

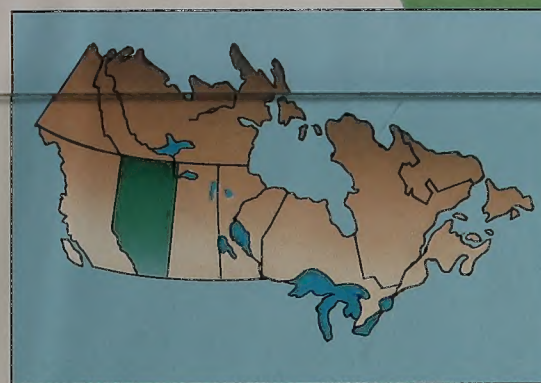
four



Steam Flood with Foam

Foam-forming surfactant is co-injected with steam. The viscous foam blocks highly transmissible channels in the reservoir, increasing the pressure differential between injector and producer wells and improving the sweep efficiency of the steam flood. The steam-foam injection program must be tailored to the recovery process and reservoir geology.

Design/illustration: Progressive Advertising Productions Ltd.



Heavy Oil Oil Sands Carbonate Trend

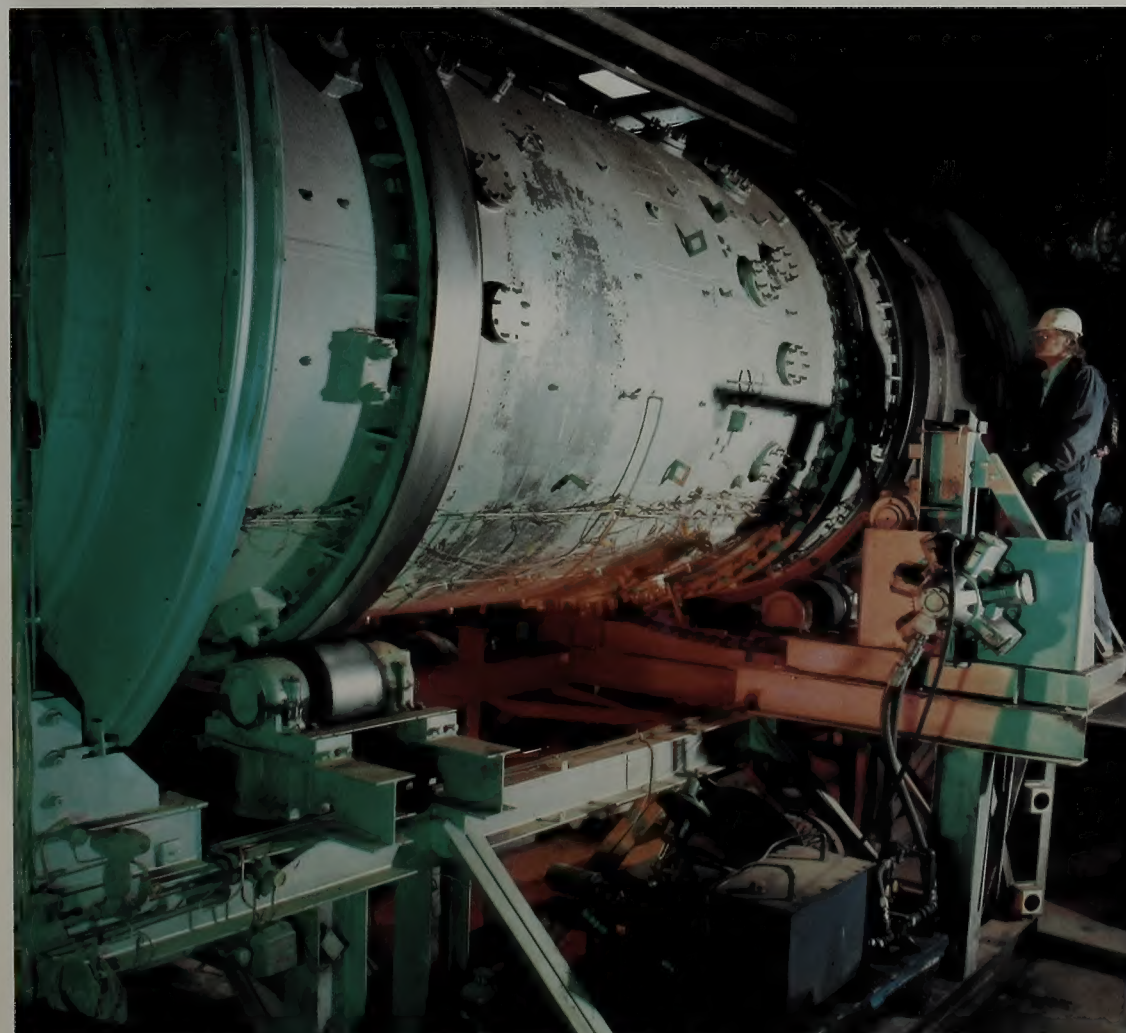
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5

Suffield Deposit

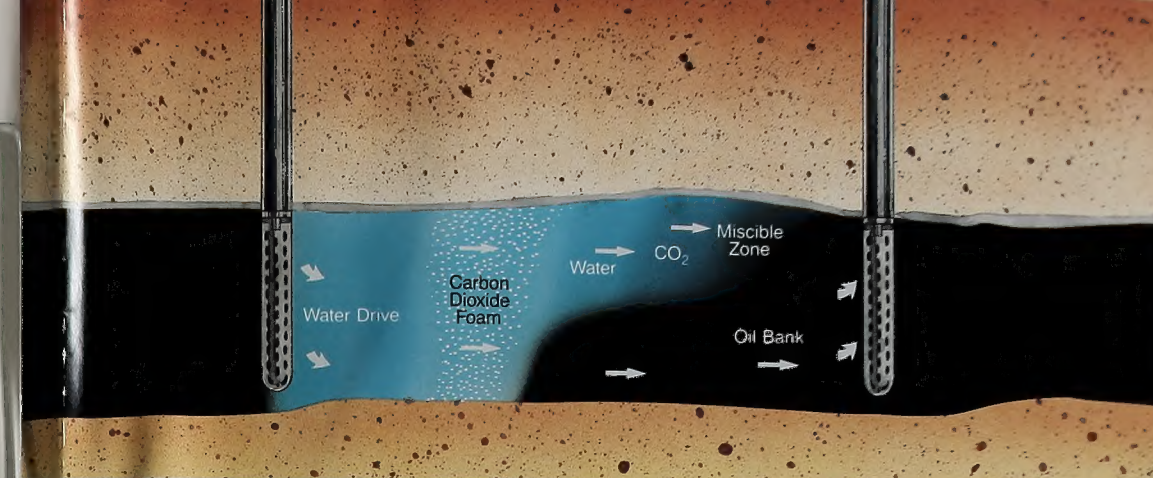
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Direct Thermal Process

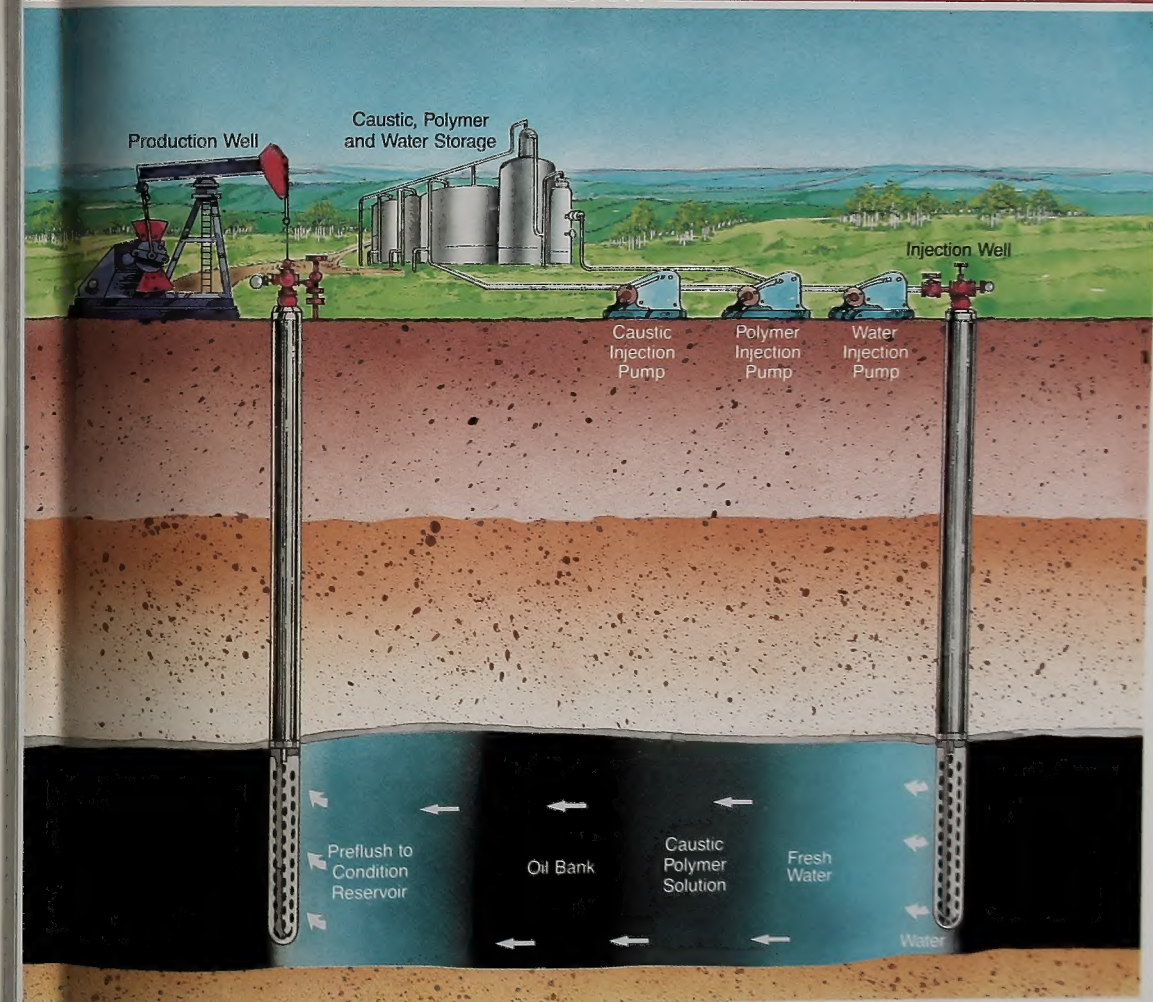
The AOSTRA TAC/UK Direct Thermal Processor for retorting mined oil sands and oil shales, simultaneously extracts and upgrades bitumen, producing a thermally cracked oil and dry tailings. These operations are accomplished in a single horizontal rotating vessel. The processor is also attractive for processing oil shales and cleanup of hydrocarbon and PCB-contaminated soils.



Miscible Flooding with CO₂ and Foam

Carbon dioxide and water are co-injected with foam-forming surfactants into a previously waterflooded oil pool. The viscous foam selectively diverts the flow of injected CO₂ through oil-bearing parts of the formation, improving sweep efficiency and oil recovery.

seven



Caustic Polymer Flooding

A reservoir salt water preflush to condition the formation is followed by the injection of a caustic polymer solution. This high-pH viscous solution reduces interfacial forces between the oil and water and minimizes channeling, thus enhancing mobility control. Water is then injected to force the caustic polymer solution and the mobilized oil to production wells.

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